MOULTON CREEK DAM NO. 1
MT -1467
AND
BASIN CREEK DAMS NO'S 1 AND 2
MT-374 MT-868
BUTTE, MONTANA

PREPARED FOR:

HONORABLE THOMAS L. JUDGE
GOVERNOR, STATE OF MONTANA

BUTTE WATER COMPANY
(OWNER AND OPERATOR)

PREPARED BY:
SEATTLE DISTRICT, U. S. ARMY CORPS OF ENGINEERS

APRIL, 1979

SEATTLE DISTRICT
UNITED STATES
ARMY CORPS OF ENGINEERS

DAM SAFETY INSPECTION

TABLE OF CONTENTS

TABLE OF CONTENTS (con.)

TABLE OF CONTENTS (con.)

TABLE OF CONTENTS (con.)

EXECUTIVE SUMMARY

Moulton Creek Dam No. 1 and Basin Creek Dams Nos. 1 and 2 are key elements in the Butte Water Company's domestic water supply system. The U.S. Army Corps of Engineers, with representation from the owners and Montana Department of Natural Resources and Conservation, inspected these facilities on 9 and 10 May 1978 under authority of P.L. 92-367, the National Dam Inspection Act dated 8 August 1972. The other dams and reservoirs in the water supply system were not inspected because they are too small to qualify under the P.L. 92-367 program.

This report has been prepared in four parts. Part I addresses general features applying to all dams. Parts II, III, and IV discuss details of each dam. The report summarizes the visual observations and review of available project documents plus engineering analyses developed during the course of report preparation. Findings were compared to engineering criteria currently in acceptance by most engineering firms and governmental agencies engaged in dam design and operation. All elevations in the report refer to Mean Sea Level (MSL).

PRINCIPAL INSPECTION FINDINGS AND RECOMMENDATIONS ARE:

a. Moulton Creek Dam No. 1: Based on its height, the inspection criteria classify Moulton Creek Dam No. 1 as intermediate in size and, because the downstream effects of failure are believed to be not excessive, the downstream hazard potential is classified as significant. Although no emergency conditions were found, the report does list deficiencies which need attention; the major deficiency being the project's inability to safely handle the recommended spillway design flood. Inspection criteria for an intermediate-sized dam with a significant downstream hazard potential requires the project to safely handle at least one-half the probable maximum flood (PMF). Reservoir routing of the preliminary PMF showed the dam was overtopped at 34 percent of the peak flow and 28 percent of the 6-hour flood volume. We believe the embankment would fail if overtopped.

A sudden release of the impoundment could jeopardize the nearby resident operator's home, but flow would then traverse an undeveloped stream course to where the Anaconda Company's Yankee Doodle Tailings Pond would intercept and contain it. This report recommends actions ranging from maintenance to engineering studies. The major recommendation is for the owners to develop a design PMF and rehabilitate the structure(s) to safely handle at least one-half the PMF. The recommended spillway design flood of at least one-half PMF is based on present day conditions. Should the downstream flood plain area be considered for further development, consideration should be given to requiring a larger spillway design flood capability or restricting new growth by appropriate zoning laws.

b. Basin Creek Dam No. 1: Based on either height or storage, the inspection criteria classifies this dam as intermediate in size. Our

visual inspection of the downstream area indicates the hazard in case of dam failure would be high. Inspection criteria requires an intermediate-sized dam having a high downstream hazard potential to safely handle the full PMF. Routing the estimated PMF shows the dam is overtopped at only 3 percent of the peak floodflow and 1 percent of the 6-hour flood volume. Dam overtopping by the PMF will not cause dam failure; however, a portion of the parapet wall on the dam's crest is expected to fail under overflow conditions. However, the type of wall failure we envision is not expected to significantly affect downstream flow. Our recommendations on this dam are, therefore, limited and consist of suggesting the parapet wall be reconstructed to be stable under all anticipated flows.

c. Basin Creek Dam No. 2: Inspection criteria classifies this dam as intermediate in size based on its height. No habitation exists downstream from the dam to the location of Basin Creek Dam No. 1. Routing the estimated PMF showed Basin Creek Dam No. 2 would be overtopped at 7 percent of the peak inflow and 5 percent of the 6-hour flood volume. The dam cannot withstand sustained overflow and will fail. The normal freeboard maintained in Basin Creek Dam No. 1 Reservoir is insufficient to contain potential flows from a failure of Basin Creek Dam No. 2. Such a failure could, therefore, cause a sudden surge over the top of Basin Creek Dam No. 1 which would create a high downstream hazard to lives and property below Basin Creek Dam No. 1. For that reason, Basin Creek Dam No. 2 is considered unsafe and the report lists deficiencies needing immediate correction. The most important recommendations deal with having the owner develop a detailed PMF and increase the project's discharge and/or storage capacity to safely handle the full PMF.

If the above recommendations to make Basin Creek Dam No. 2 safe cannot be accomplished or are significantly delayed, consideration should be given to breaching the dam to prevent further water impoundment.

R.P. Sellevold

R.P. SELLEVOLD, P.E.
Chief, Engineering Division

PART I - REPORT FEATURES THAT APPLY TO ALL DAMS

1.1 Introduction.

1.1.1 Authority. Inspection authorization is contained in the National Dam Inspection Act, Public Law 92-367, dated 8 August 1972. Nothing contained in this Act and no action or failure to act under this Act shall be construed (1) to create any liability in the United States or its officers or employees for the recovery of damages caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

1.1.2 Purpose. The purpose of the inspection and evaluation is to identify conditions that threaten public safety so that they may be corrected in a timely manner by the affected parties.

1.1.3 Inspection. This report compiles the results of visual examination of Moulton Creek Dam No. 1 on 9 May 1978, Basin Creek Dams Nos. 1 and 2 on 10 May 1978, and a review of all available design, construction, and operating data, including comments from Butte Water Company personnel and dam operators. Inspection procedures and criteria are set forth in the "Recommended Guidelines for Safety Inspection of Dams," Appendix D, Volume 1, U.S. Army Corps of Engineers' Report to the United States Congress on "National Program of Inspection of Dams," dated May 1975. The technical inspection team for Moulton Creek Dam No. 1 and Basin Creek Dams Nos. 1 and 2 was composed of the following Seattle District Corps of Engineers' personnel:

- Mr. Ralph E. Morrison, Geologist, Dam Safety Section, Foundation and Materials Branch.
- Mr. Glen J. Terui, Civil Engineer, Soils Section, Foundation and Materials Branch.
- Mr. James L. Lencioni, Hydraulic Engineer, Hydraulics Section, Hydraulics and Hydrology Branch.
- Mr. Thomas L. Samuelson, Structural Engineer, Structures Section, Design Branch.

The following Montana State Department of Natural Resources and Conservation personnel were present during the field inspections:

- Mr. Glen McDonald, Civil Engineer.
- Mr. Rick Bondy, Chief, Engineering Bureau (Inspection of Basin Creek Dam No. 1 only).

The inspection team was assisted by the following personnel as noted:

- o Mr. John Strickland, Civil Engineer, U.S. Department of Interior, Mine Safety and Health Administration (all three dams).

- o Mr. Gary Mannix, Superintendent, Butte Water Company (all three dams).

- o Mr. Mike Patterson, Engineer, Butte Water Company (Moulton Creek Dam No. 1).

- o Mr. Bob Monger, Dam Operator, Butte Water Company (Moulton Creek Dam No. 1).

- o Mr. Paul Nickerson, Regional Hydraulics Engineer, U.S. Department of Agriculture, Forest Service (Basin Creek Dams Nos. 1 and 2).

- o Mr. Andy Morrison, Resident Operator, Butte Water Company (Basin Creek Dam No. 1).

- o Mr. Norm Ward, U.S. Department of Agriculture, Forest Service (Basin Creek Dam No. 2).

- o Mr. Dean Reed, U.S. Department of Agriculture, Forest Service (Basin Creek Dam No. 2).

- o Mr. Bill Perry, U.S. Department of Agriculture, Forest Service (Basin Creek Dam No. 2).

Observer on Basin Creek Dams Nos. 1 and 2 inspections was:

- o Mr. Edward G. Chelton, Photographer, Seattle District, Corps of Engineers.

1.2 <u>Description of Project</u>.

1.2.1 <u>General</u>. The Butte Water Company was organized in 1898, and its present system is composed of a series of dams, reservoirs, and pumping plants, which supply water to the city of Butte and the Butte Mining District (plates 1 and 2). Two dams and reservoirs are located north of Butte on Moulton Creek: Moulton Creek Dams Nos. 1 and 2. Southwest of Butte, water is taken from the Big Hole River and pumped into South Fork Reservoir and then over the Continental Divide into West Reservoir, a holding reservoir. South Fork and West Reservoirs were not inspected because their sizes do not qualify them for inclusion under the Dam Safety Program. Two dams and reservoirs are located south of Butte on Basin Creek: Basin Creek Dams Nos. 1 and 2. Water is also taken from nearby creeks through gravity pipes and fed into some of the storage reservoirs. This inspection report covers one dam on Moulton Creek (Moulton Creek Dam No. 1) and both dams on Basin Creek. Moulton

Creek Dam No. 2, located about 1 mile upstream from Moulton Creek Dam No. 1, was not physically inspected because its reservoir content and location are such that a failure of the dam would not have significant downstream impact.

1.2.2 Regional Geology. The Butte, Montana, region exhibits a sampling of almost the entire geologic history of western Montana. Twenty miles south of Butte in the Highland Mountains, the 2-billion-year-old metamorphic basement complex is exposed beneath the slightly metamorphosed Belt Supergroup Sedimentary Strata which is as old as 1 billion years. The Precambrian history of the region is incomplete because of erosional intervals hundreds of millions of years in duration. The Paleozoic formations are found as remnants of formerly continuous strata deposited upon the eroded surface of the Belt Supergroup. From the time of Belt deposition through the end of the Paleozoic era, the region was a stable continental shelf close to sea level. Marine fossils indicate long-term cycles of sea level changes without deformation of the earth's crust. The Mesozoic era is represented only by thin formations of Triassic and Cretaceous sediments.

The period of stability within the crust ended in Cretaceous time with the extrusion of the Elkhorn Mountains Volcanics and equivalent volcanics surrounding the Butte area. The region was intruded by granitic plutons before the completion of the volcanic episode. Large thrust faults accompanied the granite intrusion. The mineral deposits of the region were formed between 68 to 78 million years ago during the intrusion of the granitic plutons. The main granitic mass is called the Boulder Batholith, although the formation of the batholith required repeated intrusions of granitic rocks with different mineralogies. Igneous activity ceased approximately 68 million years ago, although thrust faulting associated with the intrusions continued for several million years afterward.

The Cenozoic era has been characterized by uplift of the mountain ranges and by block faulting which may still be in progress. The result of deep erosion and down-dropped valleys has been the accumulation and preservation of intermontane lacustrine strata not consolidated into rock.

These lakebeds are common throughout the Montana Rocky Mountains. The present action of erosion has carved valleys in the lakebeds, depositing stream alluvium in the channels. Some of the higher peaks had glaciers during the last ice age, but the effects of glaciation were restricted to the mountainous areas.

1.2.3 Physiography and Climatology. The climate of the area is generally continental in nature, characterized by mild summers, cold winters, and a semiarid precipitation regime. These basins are located on the western slope of the Continental Divide.

The city of Butte, at elevation 5,540 feet, has an average July temperature of about 62° F and an average January temperature of about 15° F. Occasionally, summer temperatures exceed 100° F, and winter temperatures dip below -40° F.

Average annual precipitation at Butte is about 12 inches. Annual precipitation probably increases to about 20 to 25 inches in the Yankee Doodle and Warm Springs drainages. Thunderstorms develop on 40 to 50 summer afternoons a year. Approximately 65 percent of the annual precipitation falls in the May-September period, with approximately 25 percent of the annual amount falling in June.

1.2.4 Seismicity. Butte, Montana, is in an area of major seismic activity (seismic zone 3) and borders to the south on the active Seismic Intermountain Belt. In a 1977 report (reference 7), Charles E. Glass concluded that, based on historical earthquake data in the Butte area, ground shaking due to earthquakes will continue to occur; however, it would be unlikely that future ground motions will exceed 0.15 gravity at Butte. Studies by Glass indicate return periods of earthquakes between 30 and 60 miles of Butte would be about 3 years for magnitude of 5, 51 years for magnitude of 6, and 200 years for magnitude of 7. The maximum historic earthquake recorded (Richter magnitude of 7.1) within the Intermountain Seismic Belt occurred in 1959 near Hebgen Lake, Montana, located about 100 miles southeast of Butte.

PART II - MOULTON CREEK DAM NO. 1

TABLE 1

PERTINENT DATA - MOULTON CREEK DAM NO. 1

General	
Owner	Butte Water Company, Butte, Montana
Operator	Butte Water Company, Butte, Montana
Location	Section 19, Township 4N, Range 7W
County-State	Silver Bow, Montana
Watershed Location	Moulton Creek (Butte North quad sheet)
Purpose	Municipal Water Supply
Completion of Construction	1907
Federal Dam Register Identification Number	MT 1467
Downstream Hazard Potential Classification	Significant (2)
Principle Elevations (Feet Above Mean Sea Level)	
Top Dam (crest)	6,756
Normal Full Pool	6,747 (with one stoplog) 6,746 (without stoplogs)
Normal Minimum Pool	6,722 (approximate)
Spillway Crest	6,746 without stoplogs 6,747 with stoplogs
Reservoir	
Length of Maximum Pool	0.5 miles
Maximum Reservoir Level Experienced	Unknown
Surface Area-Normal Pool (El. 6,747 ft.)	29 acres
Drainage Area	2.64 square miles

Storage

Normal Minimum Pool (El. 6,722 ft.)	180 acre-feet
Normal Pool (El. 6,747 ft.)	686 acre-feet
Top of Dam	
Design (El. 6,756 ft.)	860 acre-feet
Actual (El. 6,756 ft.)	860 acre-feet

Spillway

Type	Uncontrolled 85-ft long concrete overflow structure. Control located in natural channel downstream from spillway structure.
Width	Varies, 18.9 feet minimum
Maximum Spillway Discharge Experienced	Unknown
Maximum Spillway Capacity (Overtopping El. 6,756 ft.)	1,370 c.f.s.

Embankment

Type	Earthfill with concrete core wall
Height (Feet Above Channel Bottom)	67
Crest Length (ft.)	500
Crest Width (ft.)	15
Downstream Slope:	
(Top 30 ft.)	1 vertical on 2 horizontal
(Base)	1 vertical on 3 horizontal
Upstream Slope	1 vertical on 2 horizontal
Volume	88,300 c.y. (approximate)

Outlet Works

Size	8-inch and 24-inch diameter Cast-Iron Pipes
Length	310 feet (approximate)
Control	Gate Valves in wet-well tower upstream from concrete core wall
Capacity at Embankment Overtopping El. 6,756 ft.	75 c.f.s.
Design Invert Elevation	6,689 feet (approximate)

CHAPTER 1 - BACKGROUND

1.1 Description of Project.

1.1.1 Site Geology. No boring logs or other subsurface exploration records exist for this project so the following comments are based on a visual examination of the area. Surface materials are sandy gravels of a granite type. Varying amounts of silt are mixed with the granular material. Very few bedrock exposures are found, but when visible, bedrock is a granite-type rock. Old mine workings or diggings show waste piles of rock fragments, and bedrock is believed to be within a few feet of the surface at least on the right valley side. The left abutment contains a spillway cut in the natural hillside. No bedrock was noted in this area or in the channel leading away from the spillway. It could not be determined if either abutment, foundation, or spillway, was tied to bedrock although surface indications suggest the dam or corewall is most likely tied to bedrock. No reconnaissance of the reservoir area was made to look for slides or potential for slides. The geotechnical evaluation, paragraph 2.3, discusses the other geologic-related subjects.

1.1.2 Description of Dam and Appurtenances. Moulton Creek Dam No. 1 is a 67-foot-high earthfill structure with a central concrete core wall. It has a crest width of 15 feet and a length of 500 feet at crest elevation 6,756 feet. On the left abutment, a concrete spillway channel discharges into an unlined channel. A stoplog near the entrance to the spillway raises the normal full-pool storage elevation to 6,747 feet. The outlet system consists of a concrete wet-well tower located upstream of the concrete core wall and 24- and 8-inch-diameter cast-iron pipes through the dam. These pipes feed directly into the water-supply line. The dam, spillway, and outlet structure were reported by Butte Water Company representatives to be founded on bedrock. Other pertinent data is contained in table 1.

1.1.3 Design and Construction History. Complete design and construction records of this project are not available. The best record, found in a reprinted report by Eugene Carrol (reference 6), indicates that the dam was constructed in 1907. According to the report, both upstream and downstream embankment slopes were constructed 1 vertical on 2 horizontal with the upstream face protected with hand-laid riprap. Embankment materials were placed in layers using wagons, sprinkled, and roll compacted. No records of embankment materials used in the construction of the dam are available. To control seepage, a central concrete core wall extending 28 feet below the creek bed was constructed. The 24-inch-diameter outlet and 8-inch-diameter blowoff pipes were embedded in concrete through the base of the dam. A plan and section view of Moulton Creek Dam No. 1 is shown on plate 3. Butte Water Company representatives reported that the original stone masonry spillway failed and was replaced by the present U-shaped reinforced concrete spillway. No records of any exploration borings were found.

CHAPTER 2 - INSPECTION AND RECORDS EVALUATION

2.1 Hydraulics.

2.1.1 Spillway. The spillway is an uncontrolled, concrete-lined chute structure, located in the left abutment of the dam (photo 1). The concrete structure is 85 feet long, transitioning in width from about 25 feet at its entrance to 18.9 feet at its terminus (see plate 4). The invert of the structure is at elevation 6,746 feet; however, a stoplog has been placed near the entrance to the structure to increase the crest control elevation to 6,747 feet. Downstream from the embankment, the spillway structure exits into a natural swale which constricts the channel and controls spillway discharges except for very low discharges which remain controlled at the stoplog. The constricted section is roughly parabolic in shape, having a top width of 27.2 feet, depth of 8.5 feet, and perimeter of 33 feet. Spillway rating was derived using backwater computations through the spillway structure with critical depth at the parabolic control section. Maximum spillway discharge at embankment overtopping elevation 6,756 feet is 1,370 cubic feet per second (c.f.s.). The spillway rating curve is shown on plate 5. Although less than half of the spillway floor could be inspected due to snow cover, visual observation indicated the floor of the concrete spillway structure is badly deteriorated, 1 to 2 inches deep in some places, most likely as a result of weathering. Sustained high discharges through the spillway probably will cause additional damage to the structure. Lesser concrete deterioration was observed on the spillway walls with minor surface spalling and cracks.

Velocities through the natural channel section downstream from the spillway structure during periods of maximum spillway discharge are in excess of 10 feet per second (f.p.s.). These velocities are sufficient to cause erosion of the natural channel materials and possible undermining and damage to the concrete spillway structure.

A small log structure located just above and near the entrance to the spillway could potentially block the spillway and result in reduced capacity if it should become dislodged during periods of high spillway discharges.

2.1.2 Outlet Works. A wet-well tower, located upstream of the concrete core wall, houses hand-operated controls for the gate valves located at the base of the tower (photo 2). Access to the wet-well tower is from the top of dam by an inverted steel queen-post truss footbridge about 45 feet long. The tower is circular, about 10 feet in diameter, and 87 feet high measured from the top of foundation. The outlet pipes consist of 8-inch- and 24-inch-diameter cast-iron pipes passing through the embankment. The 8-inch pipe passes through the embankment in a continuous run, but the 24-inch pipe terminates at the valve in the wet-well tower and then continues through the remainder of

Photo 1. Spillway

Photo 2. Wet-well tower and upstream face

the embankment as a gravity line. Both pipes feed directly to the water supply system. Additional control valves exist at the downstream toe of the embankment to operate as blowoffs to discharge at the toe of the dam during flood conditions. No means of energy dissipation exists at the blowoffs; however, erosion resulting from operation of the blowoffs is not expected to affect the embankment. Maximum capacity of the outlet at embankment overtopping elevation is 75 c.f.s. The outlet rating curve is shown on plate 6.

The pipe intakes have never been inspected to the knowledge of Butte Water Department personnel. The wet-well tower was not inspected because access to the base was not available. However, the tower is encased in steel plate below an elevation of about 6,757 feet, while the upper portion is concrete. A large crack one-half inch wide extends from the steel liner to the tower floor with smaller branch cracks. No reinforcing steel was exposed. Exterior horizontal reinforcement is provided by two circular tie bars with turnbuckles located slightly above the upper deck level.

2.1.3 Freeboard. Nine feet of freeboard exist with the reservoir at normal pool elevation 6,747 feet. The maximum fetch length on the reservoir is less than one-half mile, and estimated wave runup on the embankment resulting from wind-generated waves is 2.5 feet. Freeboard available during normal operating conditions is considered adequate.

2.2 Hydrology.

2.2.1 Basin Hydrology. The drainage basin above Moulton Creek Dam No. 1 is 2.64 square miles and is almost circular in shape. The basin is bordered on the east by the Continental Divide, with elevations to 7,760 feet. Most of the inflow to the reservoir is from natural drainage. Some flow from Pilgrim Creek, a small creek north of the dam, is diverted into the reservoir through a 16-inch-diameter pipe.

The reservoir, at normal pool elevation 6,747 feet, has a surface area of about 29 acres and a storage of 686 acre-feet. There are no gages of inflow to the reservoir.

2.2.2 Derivation of Probable Maximum Flood Estimate. Procedures contained in the U.S. Weather Bureau's Hydrometeorological Report No. 43 (reference 1) and the Weather Bureau's 1967 memorandum (reference 2) were used to compute the probable maximum precipitation (PMP). The memorandum allows for some reduction of the PMP which was not originally contained in Report No. 43. A July-August thunderstorm was selected as the most critical storm of the basin. The storm was divided into 10-minute increments and rearranged to provide a critical time sequence and produce the highest peak flow when combined with the unit hydrographs. The drainage area above the dam was divided into two subbasins, one for reservoir area and one for land area. Flow from direct

precipitation on the reservoir area was computed by conversion of the precipitation rate to a flow rate. A 10-minute triangular unit hydrograph was developed for the land subbasins by procedures outlined in U.S. Bureau of Reclamation Design of Small Dams (reference 3). Curvilinear adjustments to the triangular unit hydrographs were used. Base flow for the land subbasins was assumed equal to 5 c.f.s. per square mile, and infiltration was assumed to be a constant 0.12 inch per hour. The precipitation was applied to the unit hydrograph and the reservoir area by use of the Corps of Engineers' computer program HEC-1 to obtain the resultant flood. In addition to the floodflows from precipitation on the land, a failure of the small Moulton Reservoir No. 2 was assumed. The contents of this reservoir, 33 acre-feet, were assumed to empty in 30 minutes. The assumed dam-break hydrograph was combined with the other flows to produce a resultant preliminary PMF peak flow of 19,570 c.f.s. and a 6-hour PMF volume of 1,300 acre-feet.

2.2.3 Routing of Probable Maximum Flood. Reservoir routing of the preliminary PMF was accomplished by use of a Hydrologic Engineering Center computer program HEC-1. Floods resulting from one-half PMF were developed for the Moulton Creek Dam No. 1 drainage to aid in estimating the appropriate starting reservoir elevation for the PMF. Since one-half PMF will cause overtopping of the dam, it was assumed that the reservoir could be completely full 18 hours prior to the PMF; however, assuming full outlet capacity, all surcharge storage can be released within 18 hours. Therefore, routing of the PMF through Moulton Reservoir was started at the spillway crest. The preliminary PMF routing showed that the dam is overtopped at 34 percent of the PMF peak flow and 28 percent of the 6-hour flood volume.

2.3 Geotechnical Evaluation.

2.3.1 Dam Embankment. The observed top width and embankment slopes of the dam agree with that shown on the design drawing (plate 2). Near-surface materials on the upstream slope of the dam consist of sand with varying amounts of silt and angular gravels. Upstream slope protection is marginal at best, consisting of loose, partially decomposed, granitic rock ranging in size from pea gravel to boulders (photo 2). Grass and brush cover exist above the reservoir high-water mark (approximately 10 feet below crest). A portion of the flow in Pilgrim Creek is being diverted and conveyed to the reservoir via a buried pipe which discharges on the upstream embankment slope near the right abutment. Severe slope erosion is occurring in this unprotected outfall area. The downstream embankment slope is covered with grass and a large number of trees (photo 3). Near-surface downstream slope material varies from sand to silty sand. Minor erosion was observed in two areas on the downstream slope about 12 feet below the crest. These erosion areas may have been caused by freeze-thaw action or by surface runoff, as Mr. Monger (dam operator) reported that he has never observed seepage from the downstream embankment face, and none was observed during our inspection. An old slump was noted on the downstream slope above

Photo 3. Downstream Face

the left abutment drainage tunnel. The slump scarp, several inches deep by about 50 feet wide, is located about 8 feet below the dam crest. The downstream shoulder of the dam crest above the slump appeared to have settled about 1 to 1.5 feet. Water was ponded in ruts in the dam's crest caused by vehicles. According to the design drawing and verbal reports, seepage control through and beneath the embankment was achieved with a central concrete core wall which rises to within 8 feet of the dam's crest. Top of core wall is at elevation 6,748 feet, only 1 foot above normal full pool elevation. If the reservoir level rises above the top of the core wall and the materials above the core wall are not sufficiently impervious, water may pass over the core. Whether or not this water would cause instability problems in the downstream slope depends on whether the materials are sufficiently pervious to pass seepage without building dangerous piezometric pressures.

In the event that overtopping of the dam occurs, the sandy embankment material would easily erode away, probably resulting in total breaching of the dam.

2.3.2 Foundation and Seepage Conditions. The character of dam foundation and abutment material could not be assessed during the inspection. However, Butte Water Company representatives report that the dam and concrete spillway are founded on bedrock.

During our inspection, about 100 gallons per minute (g.p.m.) of seepage water was observed flowing from a drainage tunnel near the base of the left abutment. We understand that attempts were made to cut off the leakage by grouting during the early operating years of the dam. Remnants of old grout pipes were observed on the embankment crest near the left abutment. Whether seepage is occurring through the concrete cutoff wall or through open fissures in the reported bedrock foundation and/or left abutment is unknown. According to Mr. Monger, seepage quantities vary with pool height, but the range of variation has remained constant since his assignment to the project 28 years ago. Seepage water from the drainage tunnel was observed to be clear and no seepage from the downstream slope face was noted.

2.4 Seismic Analyses of Outlet Tower and Embankment. No analyses of the effects of earthquake forces on the stability of the wet-well tower or dam embankment are on record. Failure of the wet-well tower is not expected to affect structural stability of the dam but could result in loss of outlet capability.

2.5 Project Operation and Maintenance. Project operation information was gathered from discussion with Butte Water Company personnel, as a formal project operation program does not exist. U.S. Soil Conservation Service snowmelt runoff predictions will be used for spring refill.

2.5.1 Dam and Reservoir. Mr. Monger lives about one-fourth mile downstream of the dam. Operations are accomplished at the direction of the water company officials. Changes in settings of the outlet works are

usually required only 5 to 10 times a year. Since there is no way to refill Moulton Reservoir through another part of the water supply system, the water company attempts to keep the reservoir as full as possible. The low springtime reservoir level is about 30 feet below the spillway crest. However, the department attempts to keep the reservoir no lower than 20 to 25 feet below the spillway crest. The two outlet works pipes are tied directly to the city water system, but have blowoffs at the toe of the dam that could be operated during a flood. These blowoffs have never been used.

2.5.2 Warning System. A formal project emergency warning plan does not exist.

2.6 Potential for Downstream Damage. Overtopping of Moulton Creek Dam No. 1 would result in relatively rapid failure of the embankment, although the concrete core wall would likely slow down the failure rate to some degree. The valley downstream from the dam is essentially undeveloped. Visual observation and discussion with dam owners indicate that the dam operator's residence is the only residence subject to damage as a result of an embankment failure. The entire contents of the reservoir could be contained in the 765-acre Yankee Doodle Tailings Pond, about 4 miles downstream from the dam, resulting in an approximate 1.5-foot maximum rise in the water surface at the tailings pond, well within the normally maintained freeboard. However, Moulton Creek Dam No. 1 is a water supply facility which supplies approximately 15 percent of the area's needs, and a loss of the project could impose economic hardship and loss.

CHAPTER 3 - FINDINGS AND RECOMMENDATIONS

3.1 Moulton Creek Dam No. 1.

3.1.1 Findings. Visual inspection of the dam, examinations of records and reports, and independent analysis of the project in terms of guideline performance standards result in the findings discussed below.

3.1.1.1 Size and Hazard Potential. Based upon height, the Corps of Engineers' criteria classify Moulton Creek Dam No. 1 as intermediate in size. The National Dam Inventory for Montana identifies Moulton Creek Dam No. 1 with the designation MT-1467 and lists it as having a No. 1 (high) downstream hazard potential in case of failure. However, during the inspection, the downstream valley was found to be undeveloped and habitated by only one dwelling, and the entire reservoir contents could be safely contained in the Yankee Doodle Tailings Pond downstream from the project. Loss of the reservoir would, however, impact the area's water supply. Therefore, based upon the guidelines, the downstream hazard potential for Moulton Creek Dam No. 1 is reclassified to "significant."

3.1.1.2 Spillway.

a. The spillway capacity at embankment overtopping elevation 6,756 MSL feet is 1,370 c.f.s. An additional 75 c.f.s. can be discharged at that elevation with the outlet fully open. Routing the preliminary PMF showed that the dam is overtopped during the PMF at 34 percent of the peak flow or 28 percent of the 6-hour flood volume. Inspection program criteria requires Moulton Creek Dam No. 1 project to safely handle at least 50 percent of the PMF peak.

b. Weathering has resulted in extensive concrete deterioration on spillway floor with minor surface spalling and cracking on the walls.

c. No means of energy dissipation exists downstream from the concrete spillway structure, and prolonged spillway flow would result in erosion of the natural channel materials downstream from the structure. Possible undermining and failure of the concrete structure could occur under such conditions.

d. Spillway control is located in a natural swale downstream of the concrete-lined section.

e. A small log structure located near the spillway entrance may become dislodged and obstruct flows during periods of high spillway discharges.

f. The spillway has provision for adding flashboards to increase normal reservoir level. Normally one flashboard is utilized although several others could be placed which could raise the reservoir level above the embankment core wall.

3.1.1.3 Outlet Works.

a. No access down the wet-well tower exists.

b. Cracks exist in tower walls.

c. Wet-well tower and intake to outlet pipes have not recently been inspected.

3.1.1.4 Dam.

a. Riprap on upstream embankment face is deficient in size and quantity.

b. Severe slope erosion has occurred on the upstream right abutment face of the embankment as a result of outflow from a pipe which diverts flow into the reservoir from outside the drainage basin.

c. An old slump exists on the downstream slope above the left abutment drainage tunnel.

d. Clear seepage water was observed flowing from the left abutment drainage tunnel. No provision to measure seepage water exists. Previous attempts to cut off seepage were apparently made as evidenced by the old grout pipes which remain in the embankment crest near the left abutment. The effectiveness of this grouting program is unknown.

e. Design drawing shows that the concrete core wall was constructed to an elevation 8 feet below top of dam. Reservoir levels above top of core could cause water to flow over the core and result in possible embankment instability.

f. Trees and brush are growing on both slopes of the embankment. Roots from continued growth of these trees and brush could cause seepage problems and instability of the embankment.

g. No earthquake analyses of either the embankment or outlet works tower are on record.

3.1.1.5 Operation and Maintenance.

a. Formal operation and maintenance programs do not exist.

b. Formal project emergency warning plans do not exist.

c. The general project appearance indicates a lack of adequate maintenance.

3.1.2 Recommendations. The above findings suggest a high priority be given to the following recommendations:

3.1.2.1 Prepare and implement an emergency warning plan to alert downstream interests in the event of possible dam distress.

3.1.2.2 Accomplish the maintenance and repair work listed below as soon as materials and/or equipment can be obtained or water levels lowered:

a. Repair deteriorated concrete on spillway floor and walls.

b. Rehabilitate wet-well tower by repairing cracks in wall and provide for ease of inspection by installing lighting system (portable) and safe access to and down the tower.

c. Protect upstream slope against wave attack with additional and adequate-size riprap.

d. Discontinue diversion of Pilgrim Creek into Moulton Reservoir, or backfill and provide the eroded outfall area near the upstream right abutment with a properly designed protective riprap or concrete apron.

e. Bring the low area on the dam crest up to design elevation and fill and compact all rutted areas.

f. Clear all embankment slopes and toe of all trees and brush. Root holes should be backfilled with granular material and compacted.

g. Provide adequate protection in channel downstream from spillway structure to insure that concrete spillway is not undermined during high spillway flows.

h. Regrade downstream of spillway to establish control in concrete section. Keep channel clear of all vegetation and obstructions.

i. Relocate log structure presently located near entrance to spillway.

3.1.2.3 Conduct an inspection of the wet-well tower and pipes passing through embankment. Repair as needed.

3.1.2.4 Install and monitor a seepage weir at the left abutment drainage tunnel.

3.1.2.5 Sample and test embankment material overlying central core of the dam to determine whether or not embankment material would function as an impervious core. If studies indicate that embankment material is not competent for use as core material, replace it with suitable material so that an impervious core extends to top of dam.

3.1.2.6 Prepare and use formal project operation and maintenance plans which include periodic inspections (not to exceed 5-year intervals) by qualified engineers.

3.1.2.7 Accomplish engineering studies to determine the PMF. Modify dam and/or spillway to provide capacity to safely handle one-half PMF. The recommended spillway design flood of one-half PMF is based on present-day conditions. Should the downstream flood plain area be considered for further development, consideration should be given to requiring a larger spillway design flood capability or restricting new growth by appropriate zoning laws.

3.1.2.8 Prepare and implement an emergency warning plan to alert downstream interests in the event of possible dam distress.

PART III - BASIN CREEK DAM NO. 1

TABLE 2

PERTINENT DATA - BASIN CREEK DAM NO. 1

General

Owner	Butte Water Company Butte, Montana
Operator	Butte Water Company Butte, Montana
Location	Section 12, Township 1N Range 8W
County-State	Silver Bow, Montana
Watershed Location	Basin Creek (Butte South quad sheet)
Purpose	Municipal Water Supply
Completion of Construction	To El. 5,860 ft. in 1897 To El. 5,873 ft. in 1913 Earthfill Cover on D/S Face Placed in Early 1930's
Federal Dam Register Identification No.	MT-374
Downstream Hazard Potential Classification	High (1)

Principal Elevations (Feet Above Mean Sea Level)

Top Dam (Parapet)	5,873
Top Deck	5,870
Maximum Surcharge Pool - Design	Unknown Unknown
Normal Full Pool	5,872
Normal Minimum Pool	Unknown
Spillway Crest	5,870 (without stoplogs) 5,872 (with stoplogs)

Reservoir

Length of Maximum Pool	0.5 mile (approximate)
Maximum Reservoir Level Experienced	Unknown
Surface Area (El. 5,872 ft.) Top of stoplogs	55 acres
Drainage Area	12.4 square miles

Storage

Normal Minimum Pool	Unknown
Maximum Normal Pool (El. 5,872 ft.)	1,115 acre-feet
Top of Dam	
Design (El. 5,873 ft.)	1,170 acre-feet
Actual (El. 5,873 ft.)	1,170 acre-feet

Spillway

Type	Uncontrolled Concrete Overflow Structure with stoplogs
Width	8.5 ft
Maximum Spillway Discharge Experienced	Unknown
Maximum Spillway Capacity	
El. 5,873 ft. with Stoplogs	25 c.f.s.
El. 5,873 ft. without Stoplogs	100 c.f.s.

Dam

Type	Masonry/Concrete Arch-Gravity Dam
Height (ft. above downstream toe)	74
(ft. above lowest point in foundation)	101
Crest Length (ft.)	275

Crest Width (Dam-ft.)	5
(Parapet Wall-ft.)	1.5 at top, 2.0 at bottom
Downstream Slope (Earthfill Cover)	1 vertical on 1.75 horizontal
Upstream Slope (Masonry)	Vertical
Volume	
Masonry	11,000 c.y.
Concrete	3,600 c.y.
Earthfill	Unknown

<u>Outlet Works</u>

Size	Three 20-inch diameter Cast Iron Pipes
Length	100 ft. (approximate)
Control	Gate Valves at downstream toe
Capacity at Overtopping El. 5,873 ft.	125 c.f.s.
Elevation at outlet	5,793 ft. (approximate)

CHAPTER 1 - BACKGROUND

1.1 Description of Project.

1.1.1 Site Geology. No records of exploration work or boring logs exist for this project. The dam is built at the junction of Bear Creek with Basin Creek where granite bedrock is either exposed or lies a few feet below ground surface. Consequently, it is believed the dam rests on and is tied to bedrock on both abutments. A spillway has been cut into bedrock on the left abutment. Bedrock is exposed at numerous locations in the reservoir area and major overburden slides into the reservoir are not considered a problem. No unusual seepage or settlement was noted. Other geologic related topics are discussed in the geotechnical evaluation, paragraph 2.3.

1.1.2 Description of Dam and Appurtenances. Basin Creek Dam No. 1 is a 74-foot-high concrete-arch gravity dam with earthfill cover on its downstream face (photo 4). It contains about 11,000 c.y. of masonry, 3,600 c.y. of concrete, and 8,000 pounds of steel reinforcement. Quantity of earthfill material placed on the downstream face is not known. A concrete spillway is located in the left abutment, with stoplogs used to raise the pool. The outlet system consists of three cast-iron pipes which are regulated by gate valves located in a valve chamber at the downstream toe of the dam. Other pertinent data is contained in table 2.

1.1.3 Design and Construction History. Basin Creek Dam No. 1 was originally constructed to elevation 5,860 feet in 1897 with mortared granitic blocks. In 1913, the dam was raised to elevation 5,873 feet with addition of concrete monolithic tiers on the downstream slope. Because of concrete deterioration by freeze-thaw action, a protective earthfill cover was placed over the downstream face of the dam in the early 1930's. Subsequently, trees and vegetative growth established themselves and the dam now has the downstream appearance of an earthfill structure. A plan and section of the dam is shown on plate 7.

Complete records of either the design or construction of Basin Creek Dam No. 1 are not available. A brief history of the dam was found in a reprinted document by Eugene Carrol (reference 6).

CHAPTER 2 - INSPECTION AND RECORDS EVALUATION

2.1 Hydraulics.

2.1.1 Spillway. Basin Creek Dam No. 1 spillway (see plate 8) is an 8.5-foot-wide overflow structure located in rock near the left abutment of the dam. The spillway crest has a breadth of 5 feet at elevation 5,870 feet; however, stoplogs are placed to raise the crest to elevation 5,872 feet. A concrete bridge with a lowest concrete elevation of 5,872.75 crosses the spillway and, in conjunction with the stoplogs, limits the flow area of the spillway to an opening 8.5 feet wide by 9 inches deep. The spillway was analyzed as a sharp-crested weir (weir coefficient, C = 3.33) with stoplogs in place and a broad-crested weir (C = 2.65) with stoplogs removed. Spillway computations assume abutment contractions of 0.4 times the head on the crest. At pool elevations in excess of 5,874 feet, the spillway is assumed to have orifice control with coefficients of 0.6 to 0.75. Estimated spillway capacity at dam overtopping elevation 5,873 feet is 25 c.f.s. and 100 c.f.s. with and without stoplogs, respectively. The spillway rating curve is shown on plate 9. The dam can safely withstand reservoir elevations up to 5,890 feet (see paragraph 2.3), at which outflow is estimated to be about 60,000 c.f.s. Flow over the 275-foot-long dam was computed assuming the crest to be a broad-crested weir of varying head to breadth ratio (0 to 4.0) and having an average discharge coefficient of 3.0.

Spillway flows are conveyed over a series of steps to a chute having an invert elevation of 5,865 feet. The chute terminates in a free outfall to the canyon downstream of the dam (photos 5 and 6). The concrete surfaces of the chute and steps are badly deteriorated from weathering and are susceptible to damage from rocks falling into the structure from the rock slope into which the chute is cut. Overtopping of the 2.5-foot high chute sidewalls is possible; however, such overtopping is not expected to jeopardize the chute structure or the dam.

2.1.2 Outlet. The reservoir outlet consists of three 20-inch-diameter cast-iron pipes approximately 100 feet long. The pipes are controlled by gate valves located at their downstream ends. One pipe terminates in a free outfall at the downstream toe of the dam, with the other two pipes being connected directly to the city's water supply distribution system. The pipe inlets are on risers of various heights, the lowest (which is the direct blowoff pipe) being at elevation 5,797+ feet and the highest being about 30 feet above the base of dam. Capacity of the direct blowoff pipe is 75 c.f.s. with reservoir at elevation 5,873 (top of dam). According to water department representatives, maximum flow capacity of the other two pipes, including use of the blowoffs along the water supply line, is 50 c.f.s. Water department representatives stated that divers inspected the pipe inlets about 10 years ago and reported no deficiencies. The outlet rating curve is shown on plate 10.

Photo 4. Looking downstream at dam

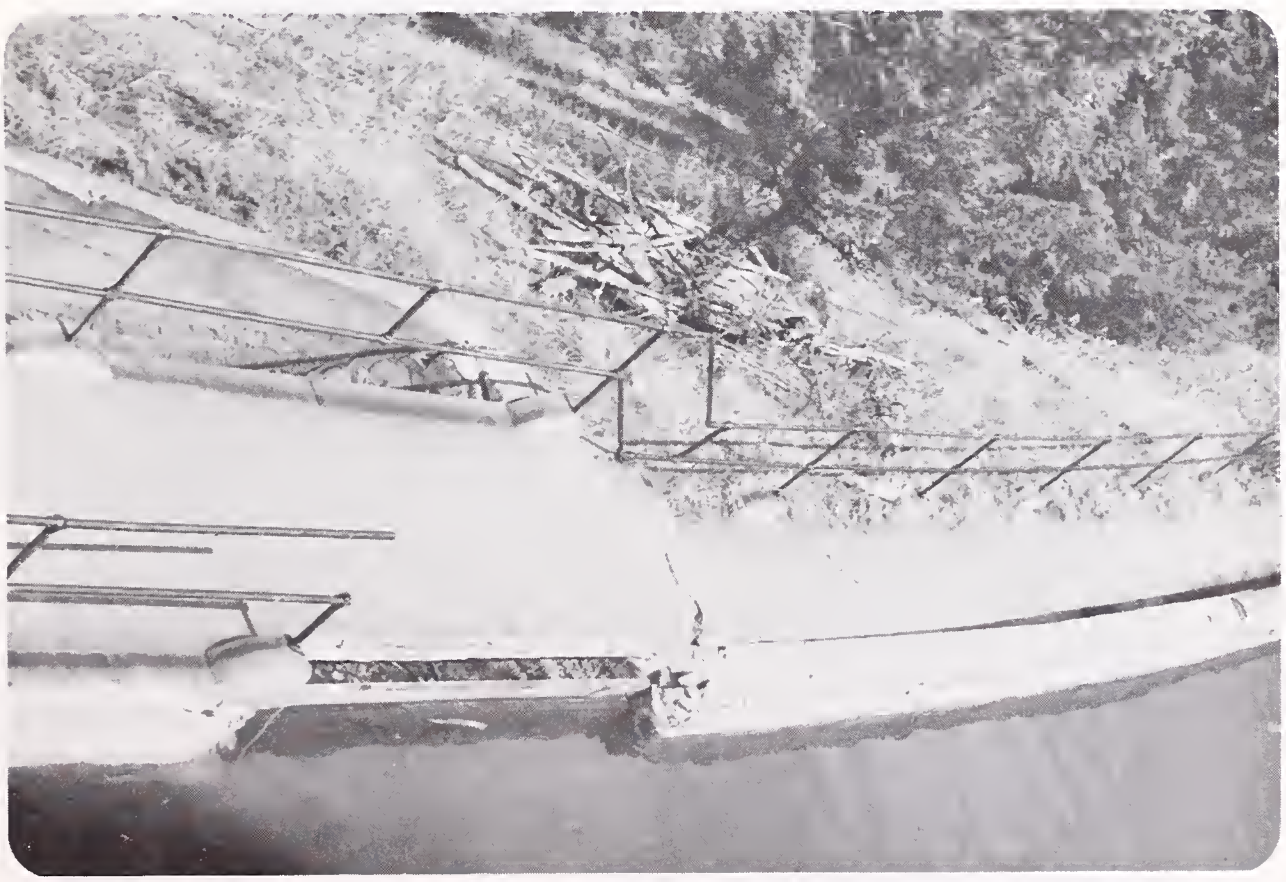


Photo 5. Plan view showing spillway intake and chute

Photo 6. Spillway chute and downstream channel looking upstream

Photo 7. Upstream elevation from left bank

2.1.3 Freeboard. At normal full pool elevation 5,872 feet, only 1 foot of freeboard exists. Wave wash over the parapet wall is quite possible; however, such overtopping would not jeopardize the safety of the structure.

2.2 Hydrology.

2.2.1 Basin Hydrology. The drainage basin above Basin Creek Dam No. 1 is 12.14 square miles, which includes 4.72 square miles above Basin Creek Dam No. 2. The basin is roughly triangular in shape and is bordered on all sides except the north by the Continental Divide. Most of the inflow to Basin Creek Reservoir No. 2 is from natural drainage. Elevations vary from 5,870 to 7,750 feet. A small diversion enters the basin from Emerald Lake on the east of the Continental Divide. Also, diversions enter Basin Creek Reservoir No. 1 from backflow from other parts of the water supply system during periods of low consumptive use.

Basin Creek Reservoir No. 1, at normal pool elevation 5,872 feet, has a surface area of about 55 acres and a storage of 1,115 acre-feet. There are gages for reservoir elevation, inflow, and outflow. Basin Creek Reservoir No. 2, at normal pool elevation 6,199 feet, has a surface area of about 14 acres and a storage of 196 acre-feet. The only inflow gage records flow diverted from Emerald Lake.

2.2.2 Derivation of Probable Maximum Flood Estimate. The same procedure was used to develop the PMP and the resultant preliminary PMF for Basin Creek Dam No. 1 as was used for Moulton Dam (see page iv). The PMF for Basin Creek Dam No. 1 required an estimate of a flood at Basin Creek Dam No. 2. The storm developed for the total Basin Creek Dam No. 1 drainage was used. A break of Basin Creek Dam No. 2 was assumed to occur when the dam was overtopped by floodflows. The maximum content of the reservoir, 290 acre-feet, was assumed to empty in 30 minutes. The hydrographs from all subbasins were combined to produce a preliminary PMF peak flow of 51,170 c.f.s. and a 6-hour PMF volume of 5,100 acre-feet.

2.2.3 Routing of Probable Maximum Flood. Routing of the PMF through Basin Creek Reservoir No. 1 was accomplished by HEC-1 and started at the spillway crest (top of stoplogs). The PMF routing showed that the dam is overtopped during the PMF at 3 percent of the peak flow and 1 percent of the 6-hour flood volume. Assuming that the upper 1-foot of the dam parapet will fail at pool elevation 5,875 feet and the dam will remain intact throughout the remainder of the PMF, the maximum pool elevation attained is 5,887 feet or 17 feet above the deck of the dam. The overflow rating curve is shown on plate 11.

2.3 Geotechnical Evaluation.

2.3.1 Dam. Basin Creek Dam No. 1 is a 74-foot-high concrete gravity rock rubble arch dam with a crest length of 275 feet. It was originally built in 1897 of large granite blocks mortared together with concrete. The water face was finished with cut stone. In 1913, the dam was raised 13 feet by placing reinforced concrete over the downstream slope. The concrete was placed in a series of steps; these steps were eroded by freeze-thaw actions and in 1934 a blanket of earth was placed on the downstream slope for concrete protection. Photo 8, taken in 1913, shows the water face of finished granite blocks and the concrete overlay. Plate 7 is a plan and section of the dam modified to reflect present conditions. The deck elevation is 5,870 feet above mean sea level. A parapet wall, on the upstream face, extends 3 feet above the deck to elevation 5,873 feet (photo 7).

2.3.1.1 Embankment Cover. Near-surface material of the downstream earthfill cover is mostly sand (photos 9 and 10). The slope is well sodded, with a large number of old trees growing on the slope. A bulge was noted along the embankment toe near the right abutment. Mr. Morrison, dam operator, reported that the bulge was material left by a slide that occurred about 30 years ago. The slide was caused by rupture of the bypass water pipeline from Basin Creek Dam No. 2 which passes over the crest and right abutment of Basin Creek Dam No. 1. The slide area has been repaired. In general, the earthfill cover appeared to be stable and in good condition.

In the event that dam overtopping should occur, the downstream earthfill cover would be at least partly washed away; however, this would not threaten stability of the concrete dam.

2.3.2 Foundation and Seepage Conditions. According to the design drawing, Basin Creek Dam No. 1 is founded on bedrock. Both ends of the dam were observed abutting against granitic bedrock. The spillway structure on the left abutment is also founded on bedrock which is competent for its usage.

A small pond of water was noted at the downstream embankment toe near the tunnel entrance to the outlet pipe control valves. Mr. Morrison reported the pond was due to minor and normal leakage of the wood-stave water supply line. No other seepage or leakage was observed.

2.3.3 Structural Stability. The dam was checked for arch dam stresses using average ring stresses described in a handbook by William P. Creager and Joel D. Justin (reference 8). The dam has a vertical upstream face and a stair-stepped downstream face. The average slope of the downstream face is about 1 vertical on .57 horizontal. The upstream face has a radius of 350 feet. This radius was checked by field measurements. The length of the dam at its crest is about 275 feet. Average arch ring stresses, neglecting cantilever restraint, were checked for the following conditions:

Photo 8. Upstream face of dam showing water face of finished granite blocks and the concrete overlay.

Photo 9. View of dam from right abutment

Photo 10. Downstream embankment cover

o Case 1. Normal water surface at deck (elevation 5,870 feet) with 10,000 pounds per square foot of horizontal ice load.

o Case 2. Overtopping condition with reservoir elevation of 5,890 feet or 20 feet above deck elevation, assuming the top 1 foot of the 3-foot-high parapet wall was lost during overtopping.

o Case 3. Earthquake condition with a force of 0.1 gravity applied normal to the upstream face in the downstream direction. Ice load was not included with earthquake loading.

2.3.3.1 Allowable Average Arch Dam Compressive Stresses. Thirty-four masonry and concrete arch dams constructed before 1917 were investigated by Mr. Creager (reference 8). Average arch ring compression stresses varied from 160 to 485 p.s.i. for 32 of the dams. Two dams had an average arch stress of 833 p.s.i. There is no record of failure of any arch dam constructed prior to this time. Average allowable stresses for Basin Creek Dam No. 1 for extreme conditions such as PMF, earthquake loading, and maximum ice load using 900 p.s.i. for the maximum allowable compressive stress are considered reasonable.

2.3.3.2 Calculated Maximum Average Compressive Stresses:

o Case 1. Normal reservoir (elevation 5,870 feet) with ice. Maximum average compressive stress of 432 p.s.i. is in tier No. 1 at the top of dam. Maximum stress in lower tiers is 242 p.s.i.

o Case 2. Overtopping condition. Reservoir 20 feet over deck (elevation 5,890.0). Maximum average compressive stress of 865 p.s.i. is in tier No. 1. Maximum stress in lower tiers is 308 p.s.i. The upper 1 foot of parapet wall was assumed eroded with top at elevation 5,872.

o Case 3. Earthquake condition. Reservoir at elevation 5,870 feet without ice. Maximum average compressive stress is 278 p.s.i. in bottom tier.

The dam is structurally safe for all design conditions, including overtopping with the reservoir 20 feet above the deck at the top of the dam. Some small cracks may develop near the top of the dam for this overtopping condition. The dam can resist earthquake forces considerably higher than 0.1 gravity with reservoir filled.

2.4 Project Operation and Maintenance. Operation and maintenance information was obtained from discussion with Butte Water Company personnel, as no formal project operation and maintenance programs exist. Also, no formal emergency warning plan exists for the Basin Creek Dams Project.

Operations are accomplished at the direction of the water company officials. Standard operating procedure is to try and keep this reservoir full until 1 July for use during the remainder of the season. The Big Hole pumping station supplies a good portion of the water to the city water system. As consumption increases during the hot days of summer, Basin Creek Reservoir No. 1 is used which helps reduce pumping costs. During August, the reservoir typically drops 0.5 to 1 foot per day. As consumptive demand decreases in the fall, the Big Hole pump continues to operate which fills Basin Creek Reservoir No. 1 through the water system. During late summer, the flow is typically out of the reservoir during the day and into the reservoir at night. Two of the outlet works pipes are tied directly to the city water system, but have blowoffs along the waterline. A third pipe is a direct blowoff at the toe. When flow over the spillway exceeds about 1 inch in depth, damage occurs to a road below the dam. When this happens, the blowoff at the toe of the dam is opened. If this is not sufficient to lower the reservoir below the spillway crest, then blowoffs along the water supply line are opened. Maintenance of the dam is accomplished as required. Plans have been made to repair the parapet wall along the top of the dam this winter; however, these repairs will not appreciably affect the conclusions made in this report.

2.5 Potential for Downstream Damage. The valley downstream from Basin Creek Dam No. 1 is relatively narrow for an initial 2 to 3 miles prior to expanding into a broad valley. Numerous residences and a county park are located in the narrow reach downstream of the reservoir and would be susceptible to damage with potential for loss of life as a result of failure of the dam. A very large railroad fill carrying the tracks of the Chicago, Milwaukee, St. Paul, and Pacific Railroad would also be jeopardized by large flows. In fact, the railroad embankment could act as a dam and if breached could cause additional flooding downstream. Overtopping of Basin Creek Dam No. 1 would not result in dam failure, although partial failure of portions of the dam parapet wall may occur during overtopping. Failure of the parapet wall during overtopping is not expected to be sudden nor to significantly affect downstream flow. The greatest potential for downstream damage from Basin Creek Dam No. 1, neglecting a structural failure, would result from sudden overtopping of the structure due to upstream causes.

CHAPTER 3 - FINDINGS AND RECOMMENDATIONS

3.1 Findings. Visual inspection of the dam, examinations of records and reports, and independent analyses of the project in terms of guideline performance standards result in the findings presented below.

3.1.1 Size and Hazard Potential. The 74-foot-high Basin Creek Dam No. 1 impounds 1,115 acre-feet of water at the normal pool elevation of 5,872 feet with stoplogs in place. At overtopping elevation of 5,873 feet, the dam would impound 1,170 acre-feet of water. The National Dam Inventory for Montana identifies Basin Creek Dam No. 1 with the designation MT-374 and lists it as having a No. 2 (significant) downstream hazard potential in case of failure. However, numerous residences, a major railroad, and a county park are located downstream from Basin Creek Dam No. 1; therefore, in the event of dam failure, economic losses and potential loss of lives would be high. Based upon the above information and in accordance with the guidelines, Basin Creek Dam No. 1 is intermediate in size and is reclassified to a downstream hazard potential of "high."

3.1.2 Spillway.

a. The spillway capacity at dam parapet wall crest elevation 5,873 feet is 25 c.f.s. with the stoplogs in place and 100 c.f.s. with the stoplogs removed. However, in practice, stoplogs are never removed. An additional 125 c.f.s. can be released through the outlet works.

b. Very low spillway discharges cause damage to a downstream road. Therefore, spillway discharge is avoided when possible by discharging through blow-off valves in the water supply lines through the dam.

3.1.3 Dam.

a. The dam will withstand overtopping from reservoir elevations up to 5,890 feet (20 feet above dam deck, 17 feet above parapet wall). Reservoir routing computations indicate that maximum reservoir elevation occurring during PMF conditions is 5,887.2; therefore, the dam is considered safe against failure resulting from overflow during the PMF even though sections of the parapet wall are likely to fail.

b. Severe spalling and cracking on the downstream face of the concrete parapet wall was noted.

c. Under full reservoir conditions, the dam can resist earthquake forces higher than 0.1 gravity.

3.1.4 PMF Routing. Routing of the preliminary PMF showed that the dam is overtopped during the PMF at 3 percent of the PMF peak flow and 1 percent of 6-hour flood volume. Even though overtopping occurs at this low percentage, the main dam is considered safe from failure until the reservoir reaches at least elevation 5,890 feet, which is adequate to pass the PMF.

Inspection program criteria requires Basin Creek Dam No. 1 to safely pass all floods up to and including the full PMF. This requirement is satisfied.

3.2 Recommendation. The above findings suggest consideration be given to repairing the parapet wall to withstand the PMF overtopping condition.

PART IV - BASIN CREEK DAM NO. 2

TABLE 3

PERTINENT DATA - BASIN CREEK DAM NO. 2

General

Owner	Butte Water Company Butte, Montana
Operator	Butte Water Company Butte, Montana
Location	Section 18, Township 1N, Range 7W
County-State	Silver Bow, Montana
Watershed Location	Basin Creek (Butte South quad sheet)
Purpose	Municipal Water Supply
Completion of Construction	1907
Federal Dam Register Identification No.	MT 868
Downstream Hazard Potential Classification	High (No. 1)

Principal Elevations (Feet Above Mean Sea Level)

Top Dam (Crest)	6,204
Maximum Surcharge	
Pool - Design	Unknown
Pool - Actual	Unknown
Normal Full Pool	6,199
Normal Minimum Pool	Unknown
Spillway Crest	6,199

Reservoir

Maximum Reservoir Level Experienced	Unknown
Surface Area (El. 6,199 ft.)	14 acres
Drainage Area	4.72 square miles

Storage

Normal Pool (El. 6,199 ft.)	196 acre-feet
Top of Dam	
Design (El. 6,204 ft.)	290 acre-feet
Actual (El. 6,204 ft.)	290 acre-feet

Spillway

Type	Uncontrolled Concrete Chute Structure
Width	15.6 ft. at entrance 13.4 ft. at control section
Maximum Spillway Discharge Experienced	Unknown
Maximum Spillway Capacity (El. 6,204 ft.)	370 c.f.s.

Earth Embankment

Type	Timber Crib and Earthfill with Concrete Core
Height (Feet Above Channel Bottom)	49
Crest Length (ft.)	320
Crest Width (ft.)	17
Downstream Slope	2 vertical on 3 horizontal (approximate)
Upstream Slope	1 vertical on 1 horizontal to 1 vertical on 2 horizontal
Volume	
Timber	46,000 lineal feet
Rock and Earth	18,445 c.y.
Rock Paving	985 square yards
Concrete Core	Unknown

Outlet Works

Size	12-inch diameter cast iron pipe
Length	90 feet (approximately)
Control	Gate Valve at downstream toe of embankment
Capacity at Overtopping (El. 6,204 ft.)	10 c.f.s.
Design Invert Elevation	6,159 (approximate)

CHAPTER 1 - BACKGROUND

1.1 Description of Project.

1.1.1 Site Geology. No records of any exploratory work or boring logs exist for this project. The dam is built at a location where granite bedrock is exposed on both abutments. The only available drawing indicates the concrete core wall extends to bedrock. A spillway has been cut in bedrock on the left abutment. A prominent set of joints striking north 10° west to north-south and dipping 70° to 85° east exists in the bedrock on the left abutment under the spillway. Seepage water finds its way through these joints and exits immediately downstream. Small alluvial fans containing sand-sized particles are found in the exit areas.

1.1.2 Description of Dam and Appurtenances and Construction History. Basin Creek Dam No. 2, located about 1-1/4 river miles (R.M.) upstream from Basin Creek Dam No. 1, is a timber crib, rock, and earthfill structure with a central concrete core wall. Construction was originally begun in 1898 as a rock-filled crib dam and reconstructed in 1907 by placing a concrete core wall upstream of the crib dam and then placing earthfill over the entire works (see plate 12). The dam is 49 feet high, with a crest width of about 17 feet and length of about 320 feet at crest elevation 6,204 feet. It contains about 46,000 lineal feet of timber, 18,445 c.y. of rock and earth, and 985 square yards of rock paving. A concrete spillway founded on bedrock is located in the left abutment. The outlet is a 10-inch cast-iron pipe regulated by a gate valve in the downstream toe of the dam. The outlet pipe discharges into the creek below the dam which flows into Basin Creek Reservoir No. 1. Complete records of either the design or construction of Basin Creek Dam No. 2 are not available. A brief history of the dam was found in a reprinted document by Eugene Carrol (reference 6).Other pertinent data is contained in table 3.

CHAPTER 2 - INSPECTION AND RECORDS EVALUATION

2.1 Hydraulics.

2.1.1 Spillway. Basin Creek Dam No. 2 spillway, located at the left abutment of the dam, consists of an irregular-shaped concrete chute structure (see plate 19 and photos 11 and 12). The spillway crest elevation is 6,199 feet. The width of the structure at its entrance is 15.6 feet and narrows to 13.4 feet at the spillway control section. Downstream from the control section, the chute walls vary in height from 2.2 to 2.7 feet, the chute narrows to 4.5 feet in width, and the slope steepens to maintain supercritical flow. Maximum spillway capacity at embankment overtopping elevation 6,204 feet is estimated to be 370 c.f.s. The spillway rating curve shown on plate 14 was developed from backwater computations through the spillway structure with critical depth at the control section and roughness coefficient, "n" = 0.02.

Upstream from the control section, the spillway structure is obstructed by brush overhanging the left wall, the remnants of a steel pipe initially intended to convey flow around the dam, and a pier supporting a wooden bridge crossing the spillway. The bridge may be readily displaced during high spillway flows and could block the spillway control section resulting in a reduction in spillway capacity. The concrete floor and walls of the spillway structure have deteriorated from weathering and would likely be further damaged if subjected to sustained high discharges. The effects of these obstructions have been included in the spillway rating computations by assuming the obstructions to result in head losses varying as functions of velocity.

At the control section, the height of chute walls are 2.2 feet and the chute transitions through an abrupt contraction; therefore, the chute walls are subject to overtopping with spillway discharges of about 70 percent of maximum capacity. Downstream from the control section, the chute becomes steep, maintaining supercritical flow. About midway down the chute, the right wall abruptly changes alinement. This geometric configuration will result in formation of a wave which will undoubtedly overtop the chute walls at discharges less than maximum spillway capacity. Brush is overhanging the left wall of the chute essentially along its entire length and will impede flow down the chute, contributing to overtopping of chute walls. Considerable erosion has occurred at the terminus of the chute because adequate means of energy dissipation does not exist. Although the above conditions will result in unacceptable flow conditions in the spillway and chute, the structure appears to be located on rock, and overtopping of the spillway chute is not expected to result in failure of the dam.

2.1.2 Outlet. The outlet consists of a 90-foot long cast-iron pipe having an inside diameter of 12 inches and is controlled by a gate valve located at the downstream toe of the embankment. The outlet pipe

Photo 11. Spillway chute (looking upstream), wooden bridge and steel pipe

Photo 12. Spillway chute (looking downstream)

and inlet to the pipe have not been inspected recently. The intake consists of a 4.5-foot square drop inlet. Maximum outlet capacity at embankment overtopping elevation is about 10 c.f.s.

2.1.3 Freeboard. At normal full pool elevation 6,199 feet, 5 feet of freeboard exists on the embankment. The maximum fetch length on the reservoir is less than one-fourth mile, and maximum wave runup on the upstream embankment face resulting from wind-generated waves is estimated to be about 3 feet. Therefore, adequate freeboard exists at normal full pool.

2.2 Hydrology.

2.2.1 Basin Hydrology and Derivation of Probable Maximum Flood Estimate. (See Part III, 2.2.1 and 2.2.2, page 27)

2.2.3 Routing of Probable Maximum Flood. Routing the PMF was accomplished by use of the Hydrologic Engineering Center computer program HEC-1. Floods resulting from one-half PMP were developed for the Basin Creek Dam No. 2 drainage to aid in estimating the appropriate starting reservoir elevation for the PMF. Since each of these floods caused overtopping of the dam, it was assumed that the dam could be completely full 18 hours prior to the PMF. However, assuming full outlet capacity, the reservoir would lower to 0.6 feet above spillway crest in 18 hours. Consequently, the PMF routing was started at elevation 5,870.6 feet and showed that the dam is overtopped during the PMF at 7 percent of the peak flow and 5 percent of the 6-hour flood volume.

2.3 Geotechnical Evaluation.

2.3.1 Embankment. The design drawings show top width of the dam as 22 feet; however, actual width is about 17 feet. Design drawings show upstream slope as 1 vertical on 1 horizontal, with riprap protection extending 3 feet above the concrete core wall. Actual upstream slope varies from 1 vertical on 1 horizontal near and at the embankment ends to about 1 vertical on 2 horizontal along the central portion of the dam embankment. At both embankment ends, riprap protection appeared to extend to the top of dam as shown on the original drawing (photo 13); however, along the central portion of the embankment, the top of riprap appeared to have settled to about 2 feet below the top of the exposed concrete core wall which is about 5 feet below the top of dam (see plate 10). Along the central portion of the upstream slope, the embankment material above the concrete core wall was slumping. Riprap appeared to be tightly interlocked and in good condition. Top of core wall is at elevation 6,201 feet, only 2 feet above normal full pool elevation of 6,199 feet. Severe storms could cause the reservoir level to rise above elevation 6,201 feet and water may pass over the core and cause instability to the downstream slope. Trees and brush were growing along the upstream edge of the embankment.

Photo 13. Upstream slope (note rock protection,slump, brush and exposed concrete cut-off wall)

The downstream slope is about as designed, with a slope of 1 vertical on 1.5 horizontal. The downstream slope is supporting a considerable number of large trees with sparse grass cover. Several animal pathways exist on the downstream slope. One pathway near the embankment toe is about 1 foot wide by 1.5 feet deep, presumably from channeling surface runoff. A depression and sinkholes were observed on the downstream slope directly above the gate valve tunnel (see plate 10). A Butte Water Company representative reported that the observed depression and sinkholes were probably the result of the embankment material caving into the old vertical access chamber to the pipeline valves. The chamber was reportedly covered with earth after a new access tunnel was completed.

Should the dam overtop, the embankment will probably fail because of the easily erodable fine-grained embankment materials. The concrete core wall and older timber crib dam would impede failure, but probably would not prevent it.

2.3.2 Foundation and Seepage Conditions. The foundation for Basin Creek Dam No. 2 is unknown; however, the design drawing does indicate the concrete core wall may extend to bedrock. While the foundation characteristics of the right abutment are unknown, the dam embankment on the left abutment appeared to be tied to exposed bedrock, and the concrete spillway structure appeared to be founded on bedrock.

During our inspection, seepage was issuing from and above the base of the rock retaining wall adjacent to the gate valve tunnel entrance (see plate 10). A Butte Water Company representative reported that this seepage exit face enlarges and rises to about 4 feet above the base of the retaining wall when the pool is held at spillway crest elevation. (Pool elevation on inspection date was elevation 6,195 feet.) Seepage was also issuing from cracks in the upstream concrete wall of the gate valve tunnel with sand deposits noted near and downstream of the tunnel entrance and outlet; however, seepage water in all cases was clear. Several ponded and wet areas were noted along the embankment toe. On the upper downstream slope near the left abutment, open-jointed bedrock was observed. The formation of a small channel and deposition of sand near the bedrock suggest that seepage with some internal erosion probably occurs during high pool conditions.

2.4 Project Operation and Maintenance. Operation, maintenance, and regulation information was obtained from discussion with Butte Water Company personnel, as no formal project programs exist. Inspection reports on Basin Creek Dam No. 2 were available and reviewed (table 4). Visits to Basin Creek Dam No. 2 are made once a week. Operations are accomplished at the direction of the water company officials. The outlet valve is shut, and the reservoir is allowed to spill once it is filled in the spring. The water remains in the reservoir until needed. This operation helps to settle turbid water and to maintain a better water quality. The reservoir is typically full 10 to 11 months

TABLE 4

SUMMARY OF PAST INVESTIGATIONS AND REPORTS
BASIN CREEK DAM NO. 2

Subject	By
Basin Creek Dam No. 2 Inspection Report (13 October 1977)	Walter J. Sonntag
Basin Creek Dam No. 2 Inspection Report (28 September 1972)	Earl R. Williams
Basin Creek Dam No. 2 Inspection Report (11 June 1969)	Earl R. Williams
Basin Creek Dam No. 2 Inspection Report (25 October 1966)	Jerome B. Knaebel
Basin Creek Dam No. 2 Inspection Report (3 December 1941)	N. Templer

per year. The reservoir is lowered in the spring in anticipation of the snowmelt runoff predicted by the Soil Conservation Service. Maintenance is accomplished as required. Access to the dam is restricted to 4-wheel drive trails and foot paths. Weather further restricts access during winter months.

2.5 Potential for Downstream Damage. There is no habitation or development between Basin Creek Dam No. 2 and Basin Creek Reservoir No. 1. However, a failure of dam No. 2 would result in overtopping of Dam No. 1. This sudden overtopping would cause a significant increase in downstream discharge and create a potential threat to life and property.

CHAPTER 3 - FINDINGS AND RECOMMENDATIONS

3.1 Findings. Visual inspection of the dam, examination of records and reports, and independent analyses of the project in terms of guideline performance standards result in the findings presented below.

3.1.1 Size and Hazard Potential. Based on height, the inspection guidelines classify Basin Creek Dam No. 2 as intermediate in size. The National Dam Inventory for Montana identifies this dam as MT-868 and lists it as having a significant (No. 2) downstream hazard in case of failure. The valley downstream from Basin Creek Dam No. 2 is undeveloped and leads to Basin Creek Reservoir No. 1. However, failure of Basin Creek Dam No. 2 could cause Basin Creek Dam No. 1 to be overtopped resulting in potentially high economic losses and possible loss of lives. Based upon the above information and in accordance with the guidelines, Basin Creek Dam No. 2 is reclassified to have a downstream hazard potential of "high."

3.1.2 Spillway.

a. The spillway capacity at embankment crest elevation 6,204 feet is about 370 c.f.s. An additional 10 c.f.s. can be discharged through the outlet works.

b. The low wall at the control section of the spillway will overtop at about 70 percent of maximum spillway capacity, possibly resulting in flow impinging on downstream embankment face.

c. Numerous flow obstructions exist in the spillway structure and reduce spillway capacity. Spillway is susceptible to blockage from a possible failure of the timber bridge crossing the structure and from buildup of trash around the center pier.

d. Concrete deterioration on spillway floor is extensive.

e. Undermining at the toe of spillway chute is occurring.

3.1.3 Outlet. No energy dissipator exists at the outlet terminus.

3.1.4 Inlet. The drop inlet has, to the best of our knowledge, not been inspected since its construction.

3.1.5 PMF Routing. Routing of the PMF showed that the dam is overtopped during the PMF at 7 percent of the peak flow and 5 percent of the 6-hour flood volume. We believe the dam will fail with overtopping floodflows. Failure of this dam could cause a surge over Basin Creek Dam No. 1 which would result in a potentially destructive wave downstream.

3.1.6 Dam.

a. Seepage was flowing from the rock retaining wall adjacent to the gate valve tunnel entrance.

b. Seepage was issuing from cracks in the upstream concrete wall of the gate valve tunnel.

c. Ponded areas exist along the embankment toe.

d. Open-jointed bedrock exists on the upper downstream slope near the left abutment. A dry channel with deposition of sand near the bedrock joints indicates that seepage and possible internal erosion probably occur during high-pool conditions.

e. The upstream slope with riprap protection appeared to have slumped a maximum of about 2 feet below top of concrete core wall. Core wall is exposed in this area.

f. Spalling of concrete core wall was found on the exposed upstream face.

g. Trees and brush are growing on both upstream and downstream embankment slopes.

h. Animal pathways exist on the downstream slope.

i. A depression and sinkholes exist on the downstream slope above the gate valve tunnel.

j. Top of concrete core wall is only about 2 feet above the normal full-pool level. Pool levels above top of core could cause water to flow over the core and cause embankment instability.

k. Access to the dam is limited to foot traffic some times of the year.

3.1.7 Seismic Analyses. No seismic analyses of the dam embankment are on record.

3.1.8 Operation and Maintenance.

a. Formal project operation, maintenance, and emergency downstream warning plans do not exist.

b. The general project appearance reflects a lack of adequate maintenance.

3.2 Recommendations. The above findings suggest a high priority be given to the following recommendations:

3.2.1 Immediately develop and implement an emergency downstream warning plan.

3.2.2 Accomplish the maintenance and repair work listed below as soon as materials and/or equipment can be obtained or water levels lowered.

a. Provide adequate protection in channel downstream of spillway structure to prevent further undermining.

b. Improve or eliminate bridge over spillway to insure stability during spillway discharges.

c. Inspect inlet to outlet pipe and pipe itself to insure against seepage into embankment materials.

d. Clear all embankment slopes and toe of trees and brush. Backfill root holes with granular material and compact.

e. Fill and compact pathways formed by animals on the downstream slope.

f. Raise spillway chute walls as required to safely contain flows up to maximum spillway capacity.

g. Raise settled upstream slope with appropriate embankment material and protect with riprap.

h. Remove all obstructions in and along spillway and chute.

The above recommendations (3.2.1 through 3.2.2) will not make the dam safe, but will reduce the risk to life and property while the following recommendations are being taken.

3.2.3 Perform engineering studies to:

a. Determine and evaluate embankment and foundation materials and conditions. Special attention should be given to the observed upstream slope settlement and downstream seepage areas and to the observed open rock joints in the left abutment. The investigation and study should include: exploration; sampling; testing; analyses by qualified soils engineers; installation and monitoring of piezometers in the embankment, foundation and abutments; and installment of weirs in the spring areas to permit measurement and evaluation of piezometric and seepage conditions.

b. Sample and test embankment material overlying central core to determine whether or not embankment material would function as an impervious core. If studies indicate that embankment material is not competent for use as core material, extend core to top of dam.

c. Develop a detailed PMF and modify the discharge and/or storage capacities to safely handle the PMF.

3.2.4 Prepare a program for periodic inspections at least once every five years, to detect conditions of signiificant structural stress and operational inadequacy. This detailed inspection to be accomplished by engineers or other technical experts.

3.2.5 If the dam is not made safe within a reasonable period of time, remove the dam to protect downstream life and property.

REFERENCES

1. U.S. Weather Bureau, Hydrometeorological Report No. 43, Probable Maximum Precipitation, Northwest States, Washington, D.C., 1966.

2. Memorandum, U.S. Weather Bureau, Hydrological Branch, Office of Hydrology, subject: Probable Maximum Thunderstorm Rain for the Columbia River Basin East of the Cascade Ridge, 20 September 1967.

3. U.S. Bureau of Reclamation, Design of Small Dams, 2d Edition, 1974.

4. U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-1 Flood Hydrograph Package, Davis, California, January 1973.

5. Pacific Northwest River Basins Commission, Columbia-North Pacific Region Comprehensive Framework Study, September 1972.

6. Carrol, Eugene. "The Water Works Plant of Butte, Montana," reprinted from the Journal of the American Water Works Association, Vol. 17, No. 3, March 1927, pp. 371-387.

7. Glass, Charles E., Geological Engineer. Earthquake Risk for Butte, Montana, prepared for Pincock, Allen, and Holt, Inc., February 1978, 17 pp. with Figures and Appendix.

8. Creager, William P., and Justin, Joel D. Hydroelectric Design Handbook, copyrighted 1927.

BUTTE WATER COMPANY

124 WEST GRANITE STREET · P.O. DRAWER 398

BUTTE, MONTANA - 59701

March 8, 1979

Department of the Army
Seattle District, Corps of Engineers
P. O. Box C-3755
Seattle, Washington 98124

RE: Dam Inspections of 9 and 10, May 1978

Gentlemen:

In general, the Butte Water Company agrees with and will implement most of the Army Corp of Engineers' recommendations. These will be accomplished as priorities are established, and available manpower permits. Before attention is given to each individual reservoir, I would like to make some general comments common to all three.

PROJECT OPERATION AND MAINTENANCE PLANS

At present, formal operation and maintenance plans, and personnel responsibilities are being prepared for all segments of our organization.

EMERGENCY DOWNSTREAM WARNING

All major reservoirs in the Water Company system are manned on a 24-hour day -- 7-day week basis with experienced personnel living on site, in company housing. In the event of impending problems, these watchmen will notify our shop, which is also manned 24 hours per day, 7 days per week; in turn, the engineer on duty will immediately notify the proper authorities and any persons located in the affected areas.

MOULTON CREEK DAM NO. 1

Section 3.1.1.1 Size and Hazard Potential, states that, "The entire reservoir contents could be safely contained downstream; however, the loss of the reservoir would adversely impact the areas water supply". Unknown to the Corp, the Butte Water Company has provisions within its system to supply water to that area in the event of a problem. We have done this for extended periods during years of low runoff.

Prior to the inspection, we had acquired steel pipe that will be used to divert the Pilgrim Gulch water away from the embankment after the eroded area is filled with suitable material.

Dam Inspections
Page Two
March 8, 1979

BASIN CREEK DAM NO. 2

We are now in the final stage of completing construction of a new 36" water line from the Big Hole Pump Station to Butte; projected completion of the project is the fall of 1980. This pipeline will deliver 5 million gallons daily additional water to the city. Therefore, we will no longer need the additional storage of Basin Creek Dam #2. When the pipeline is completed and operating, we will BREACH Basin Creek Dam #2, at a level above the accumulate sand and sediment, to prevent increased turbidity levels in Basin Creek #1 Reservoir.

BASIN CREEK DAM NO. 1

During the inspection of Basin Creek Dam #1, we informed the Army Corp of Engineers that the reconstruction and repair of the parapet wall was planned for the near future. Design of the wall is completed and repair work will begin as soon as manpower is available.

Ice loading on the dam is not a factor, since compressed air is bubbled along the face of the dam when icing conditions exist; therefore, no ice forms within 10 - 15 feet of the dam's face.

Thank you for the opportunity to comment on the inspection report.

Very truly yours,

Gary W. Mannix

Gary W. Mannix,
Superintendent

GWM/df

Bm

February 23, 1979

Sidney Knutson
Assistant Chief, Engineering Division
Corps of Engineers
Post Office Box C-3755
Seattle, Washington 98124

Dear Mr. Knutson:

As per your letter dated February 12, 1979, the subject report has been reviewed and the following comments are submitted:

1. Page 18 -- Basin Creek Dam No. 1 is located in Range 8W rather than Range 7W as shown.

2. Page 7 -- The small cast iron pipe is 4 inches in diameter not 8 inches (see Plate 3).

3. Page 35 -- The cast iron pipe is 12 inches in diameter not 10 inches (see Plate 12).

4. The author's major concern is the reservoir routing calculations for Moulton Creek Dam No. 1. As shown on page 6, the reservoir capacity at elevation 6754 is 860 acre-feet. Constructing a straight line through given reservoir capacities at elevations 6746, 6749, and 6751, a conservative estimate of the capacity at elevation 6754 would be about 946 acre-feet.

The retention rate of 0.12 inch per hour is similar to using a curve number of about 94 when establishing the storm hydrograph by the SCS method. A curve number of about 60 would be acceptable for this particular drainage basin.

Sincerely,

John E. Strickland
Civil Engineer
Mine Waste Branch
Denver Technical Support Center

cc: S. A. Stanin
J. Mulhern

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FEDERAL BUILDING MISSOULA, MONTANA 59807

7530
2720

MAR 19 1979

Department of the Army
ATTEN: Mr. Sidney Knutson, P.E.
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124

Dear Mr. Knutson:

We have reviewed the final draft reports for Moulton Creek Dam No. 1 and Basin Creek Dams Nos. 1 and 2, and concur with the findings and recommendations in the reports.

Regarding Basin Creek Dam No. 2, we are advised that the Butte Water Company will breach the dam in the fall of 1980 when completion of a pipeline from the Big Hole River is expected. We believe the scheduled construction is timely; however, interim safety measures in the form of an "emergency action plan" and/or an operation plan will be required of the Butte Water Company until the dam is safely breached.

If we may be of future service, please let us know.

Sincerely,

for R. W. LARSE
Regional Engineer

March 30, 1979

Ralph Morrison
Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, WA 98124

Dear Mr. Morrison:

The Department of Natural Resources and Conservation has reviewed the Moulton/Basin Creek reports. Our review comments are listed below.

A. In the executive summary who was the team leader?

B. Photo 5 on Page 21 for Basin Creek No. 1 - It is hard to determine exactly what photo is showing based on tilted angle of camera.

C. This is a general comment on Basin Creek No. 1. On Page 23, Paragraph 1.1.1 the report states it is believed the dam and abutments rest on bedrock. If it is not known for sure the composition of the abutments, it would be difficult to speculate positively that the dam is safe against prolonged overtopping from a PMF. Subsurface investigation may be required before positive statements can be made regarding the dam stability under 17 feet of overtopping from a PMF. (Page 24, Paragraph 2.2.3) The Department agrees with computations regarding the dams apparent structural soundness but questions abutment stability during overtopping.

D. Under Chapter 3 - Recommendations, does the Corps feel the trees should be removed from the downstream face? Could tree roots enter existing cracks in the dam face (if there are in fact any) and spread these cracks further or is the slope stability these trees offer more important?

E. This is a general comment on Basin Creek, No. 2. On Page 42, previous Forest Service Inspection reports are listed. In the report these inspection reports were not discussed. What problems were encountered and what recommendations were made regarding the safety and maintenance of the dam based on finding from these reports?

F. On Page 41, second paragraph under 2.3.2 - Is plate 10 the correct plate number?

Sincerely,

Richard L. Bondy

Richard L. Bondy, P.E.
Chief, Engineering Bureau

RLB:GM:mb

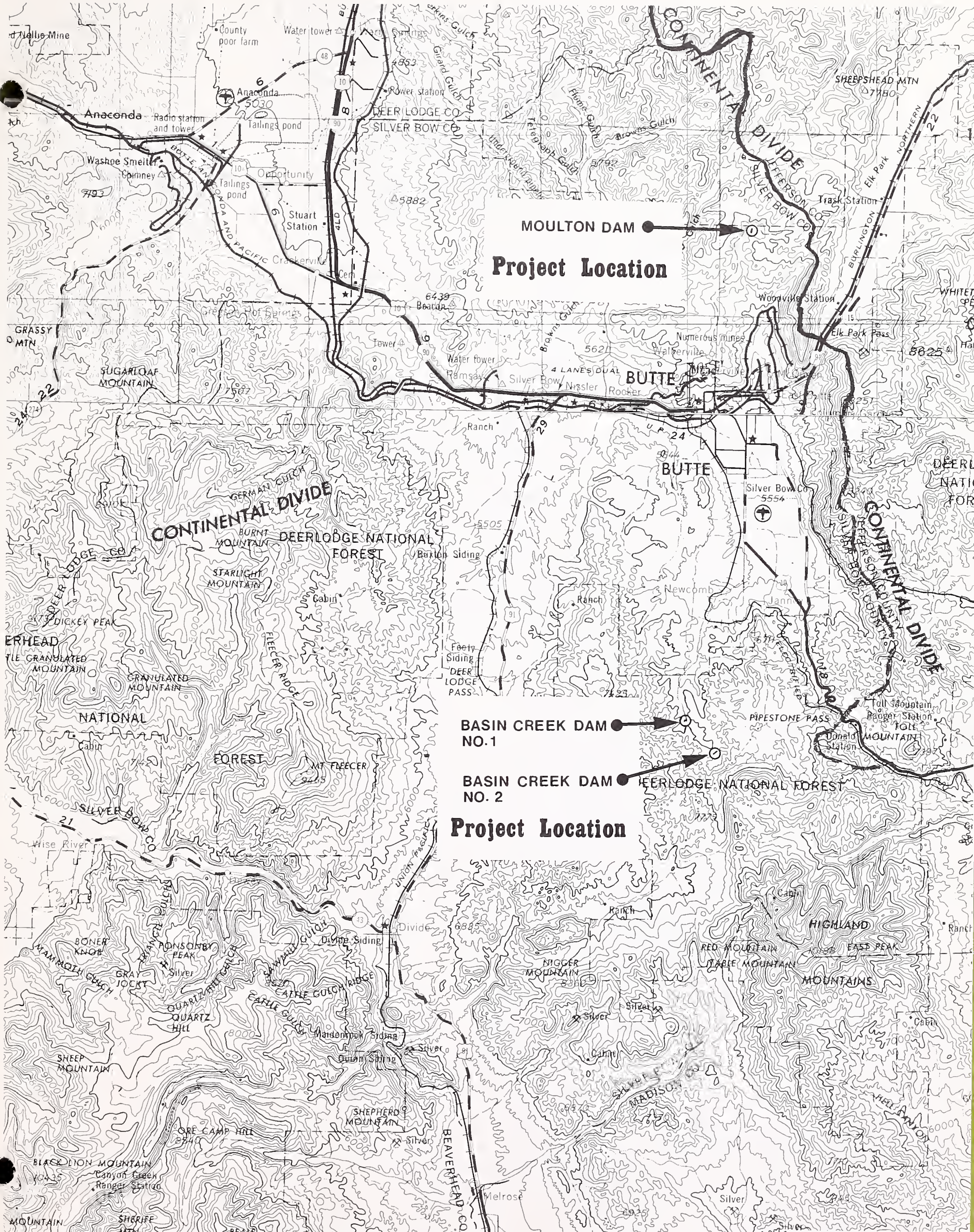
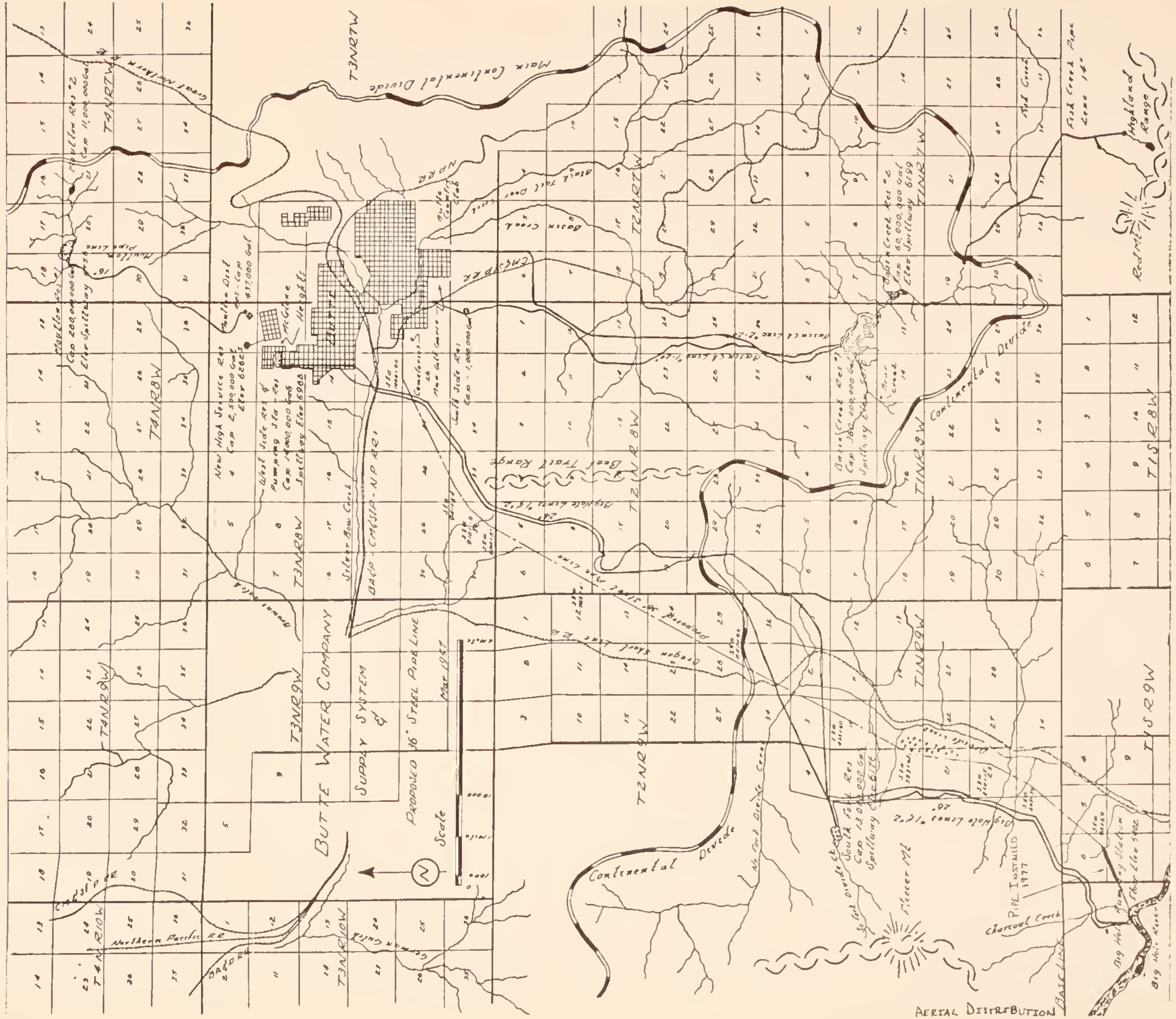
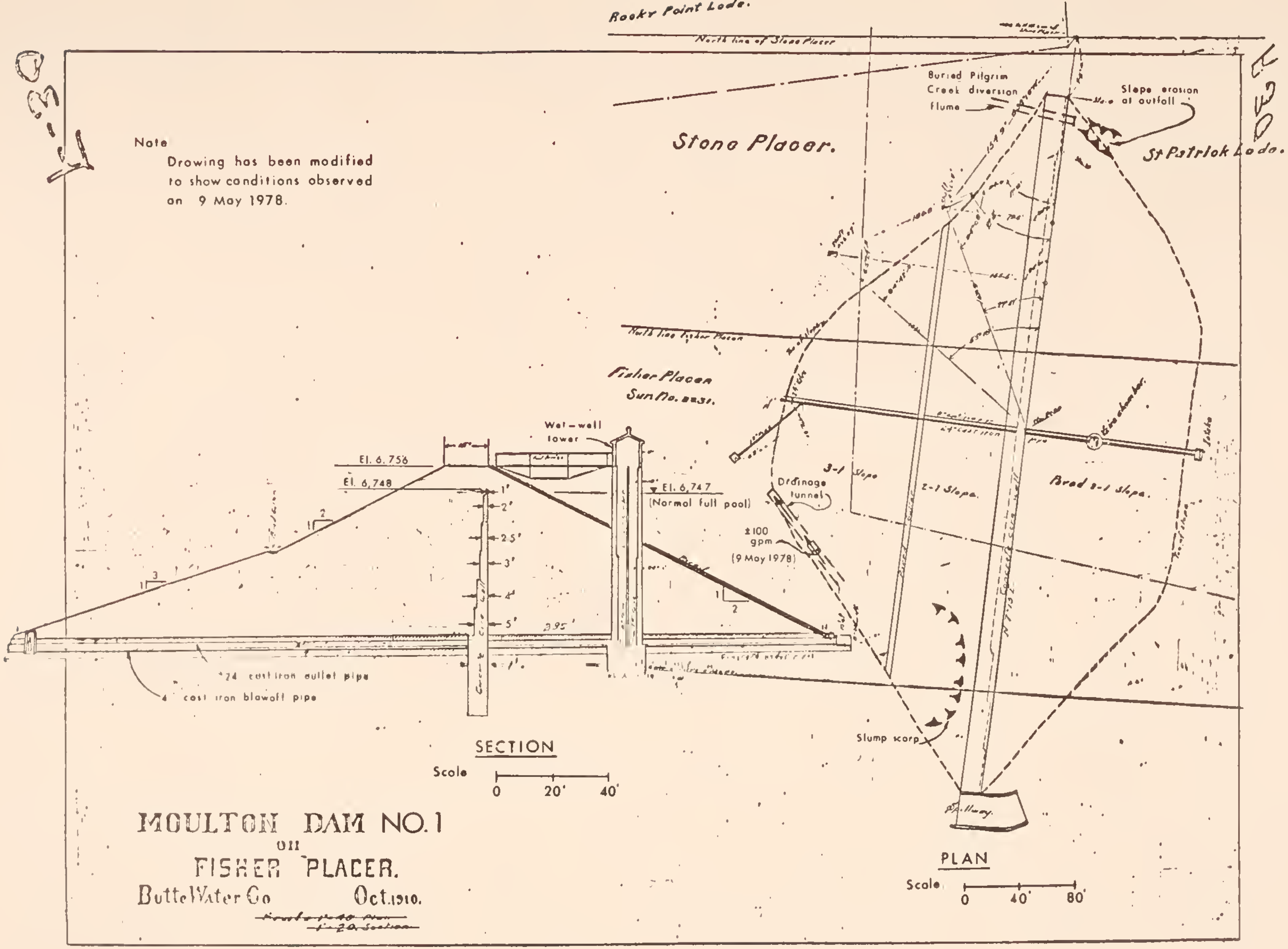

MOULTON DAM
Project Location
BASIN CREEK DAM NO.1
BASIN CREEK DAM NO. 2
Project Location
Anaconda
BUTTE
CONTINENTAL DIVIDE
DEERLODGE NATIONAL FOREST
HIGHLAND MOUNTAINS
PIPESTONE PASS
DEER LODGE PASS
SILVER BOW CO
BEAVERHEAD COUNTY
Divide
Melrose

PLATE 1

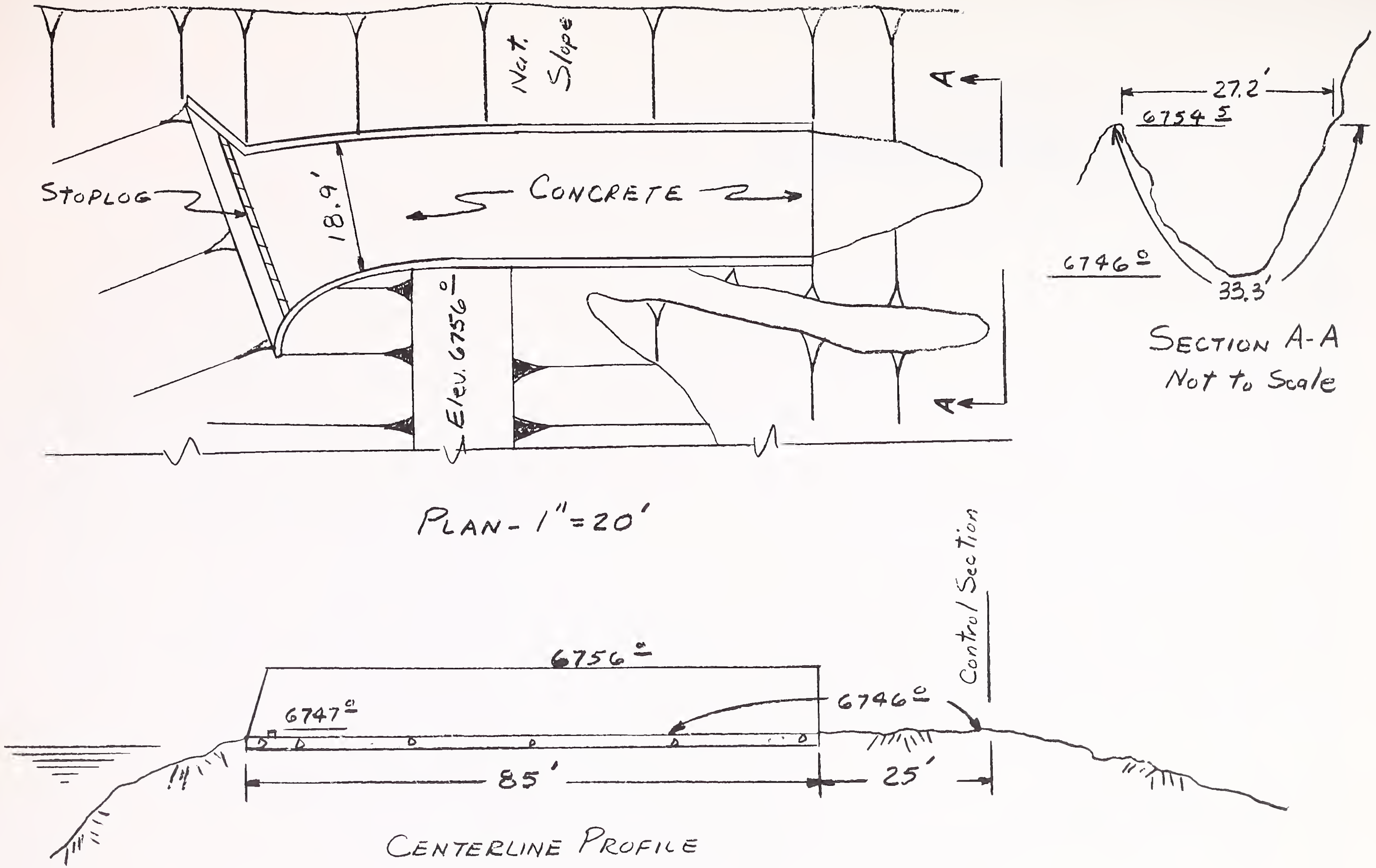


AERIAL DISTRIBUTION
PLATE 2



PLAN AND SECTION

PLATE 3

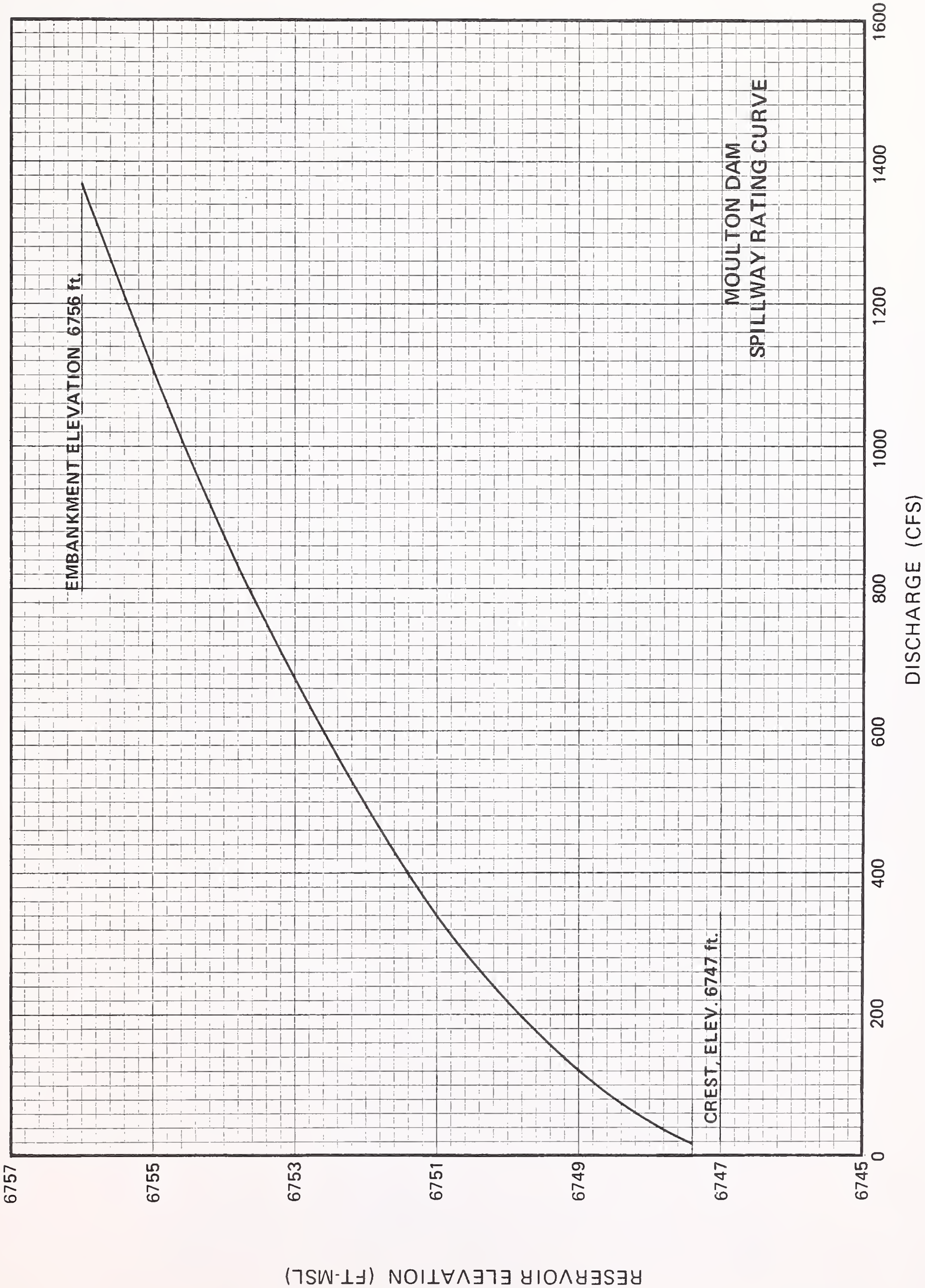


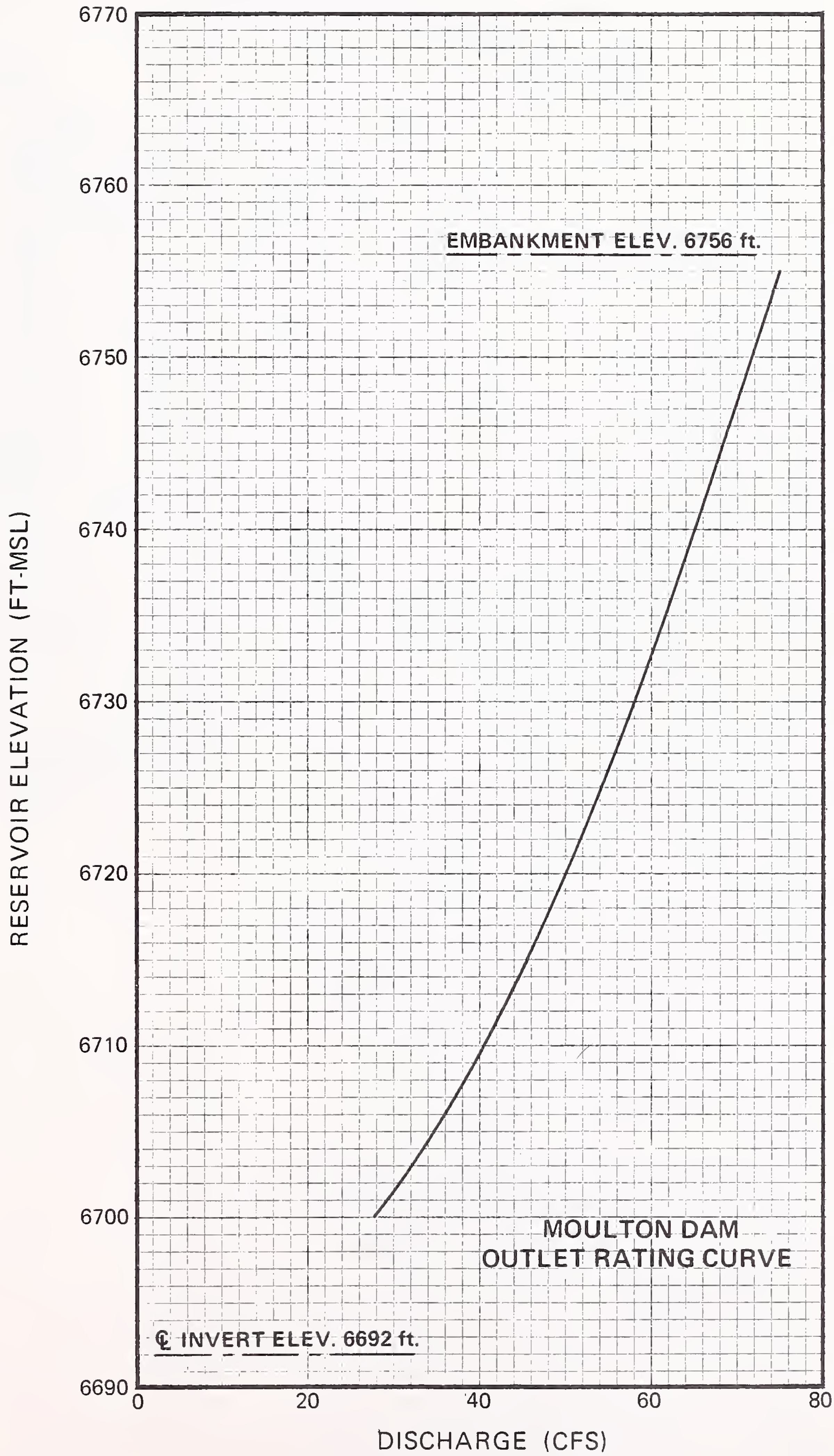
Plan - 1" = 20'

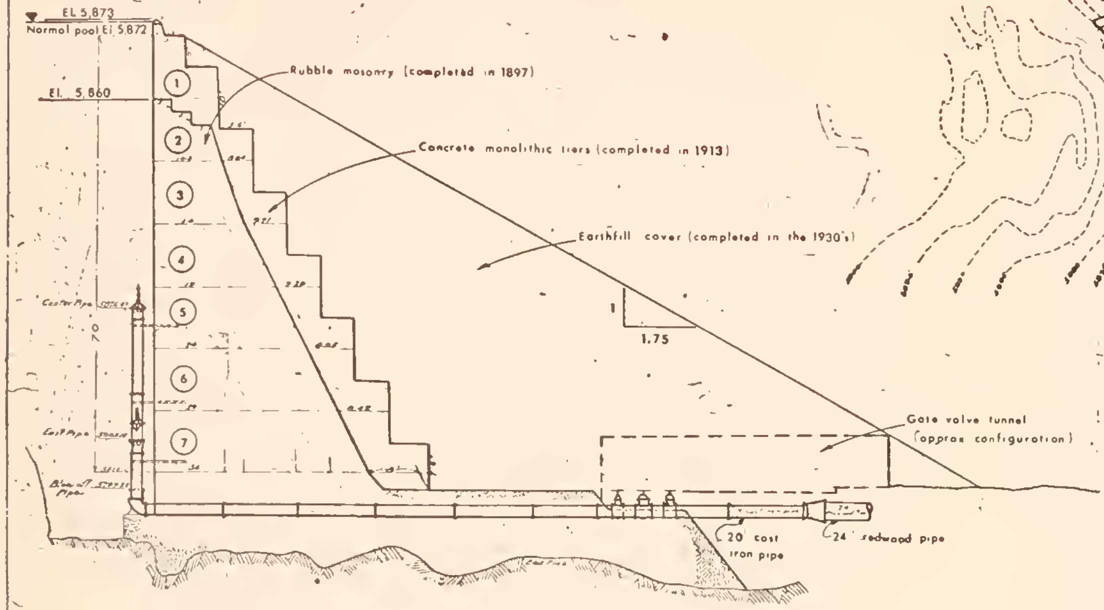
Centerline Profile
1" = 20'

Moulton Dam
Spillway

PLATE 4

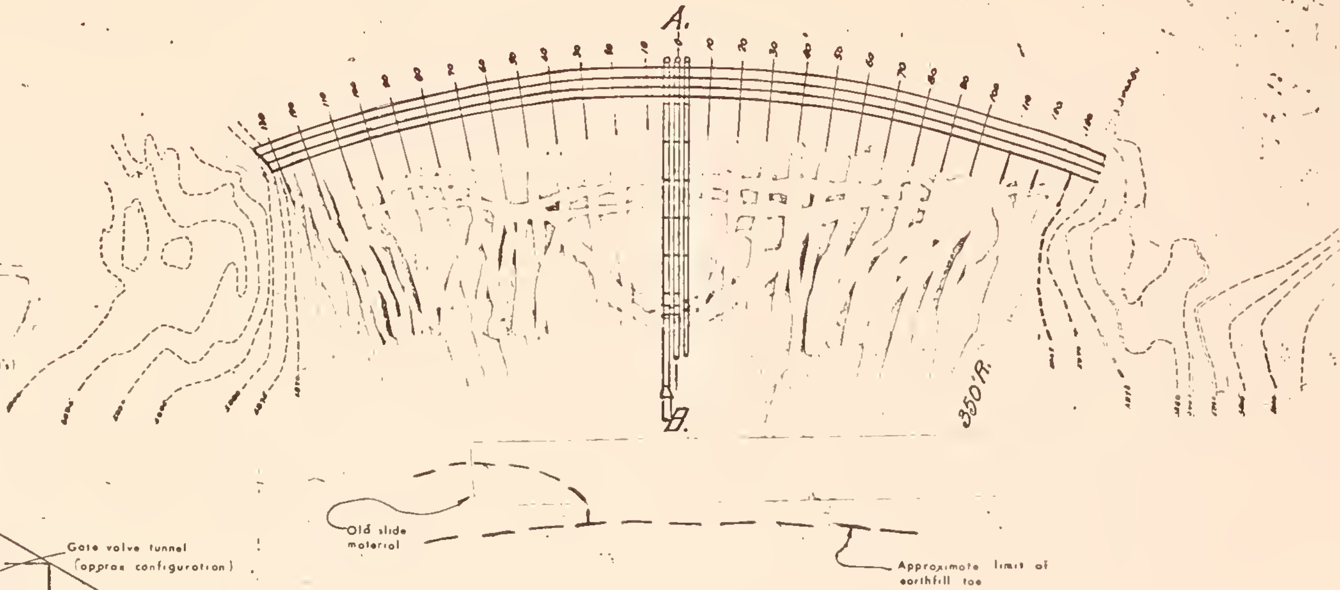

MOULTON DAM
SPILLWAY RATING CURVE
EMBANKMENT ELEVATION 6756 ft.
CREST. ELEV. 6747 ft.
DISCHARGE (CFS)
RESERVOIR ELEVATION (FT-MSL)
0
200
400
600
800
1000
1200
1400
1600
6745
6747
6749
6751
6753
6755
6757


6770
6760
6750
6740
6730
6720
6710
6700
6690
0
20
40
60
80
RESERVOIR ELEVATION (FT-MSL)
DISCHARGE (CFS)
EMBANKMENT ELEV. 6756 ft.
℄ INVERT ELEV. 6692 ft.
MOULTON DAM
OUTLET RATING CURVE



SECTION OF DAM

Scale 0 10' 20'



PLAN OF DAM

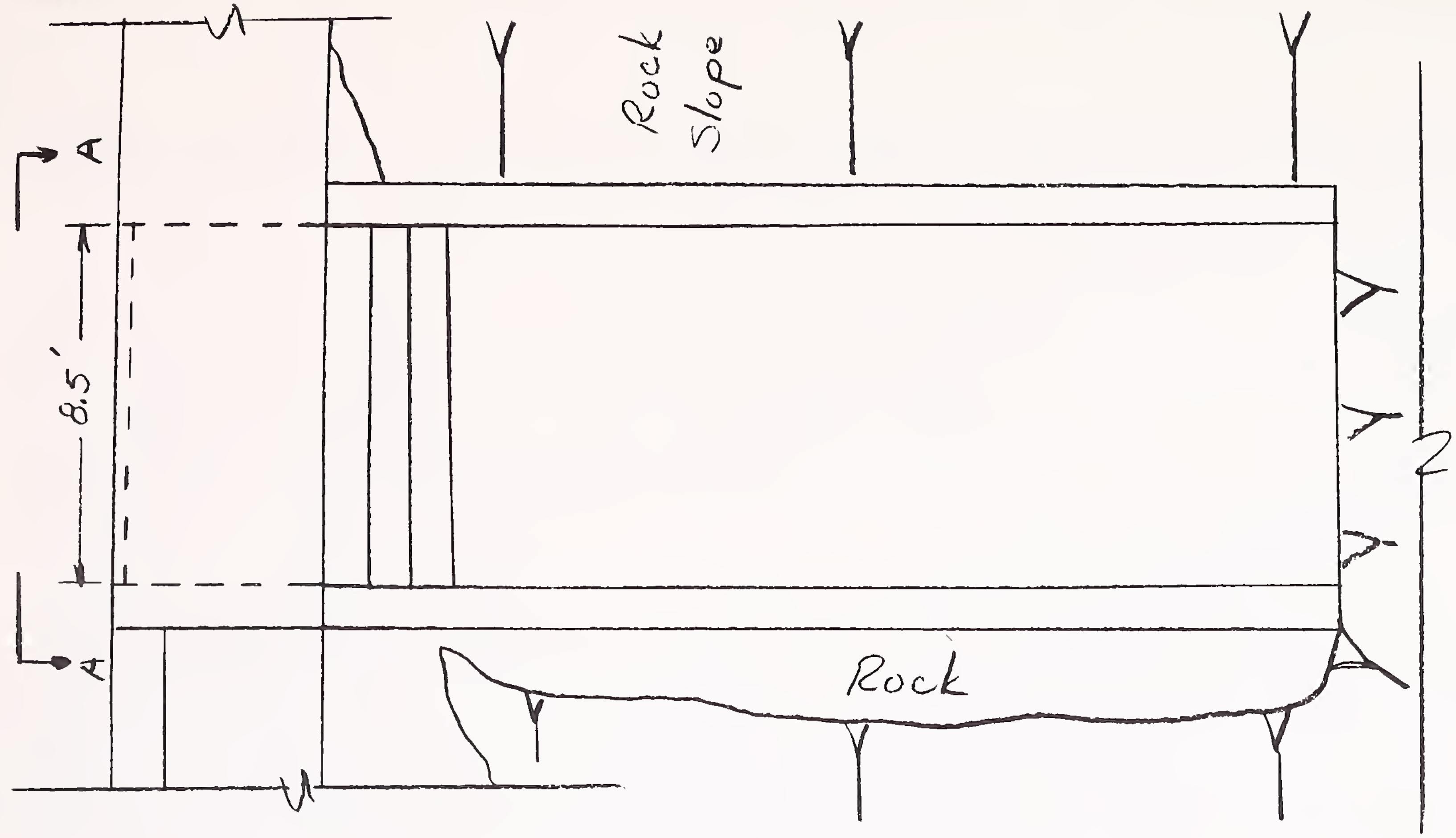
Scale 0 20' 40'

Note
Drawing has been modified to show conditions observed on 10 May 1978

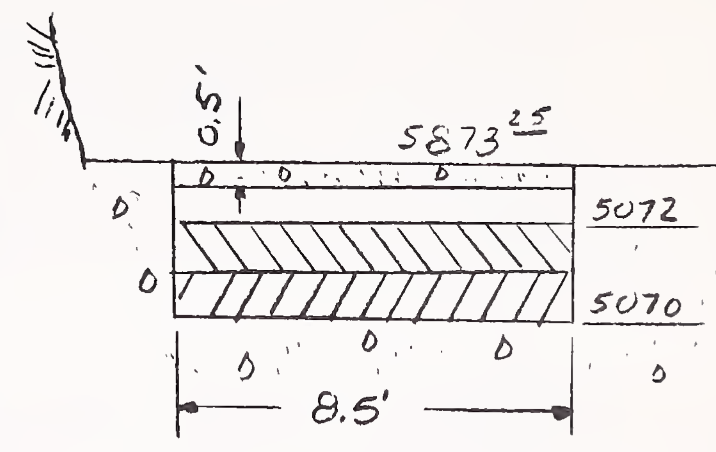
BASIN CREEK DAM NO. 1
PLAN & SECTION

BUTTE WATER CO. DEC. 12, 1912

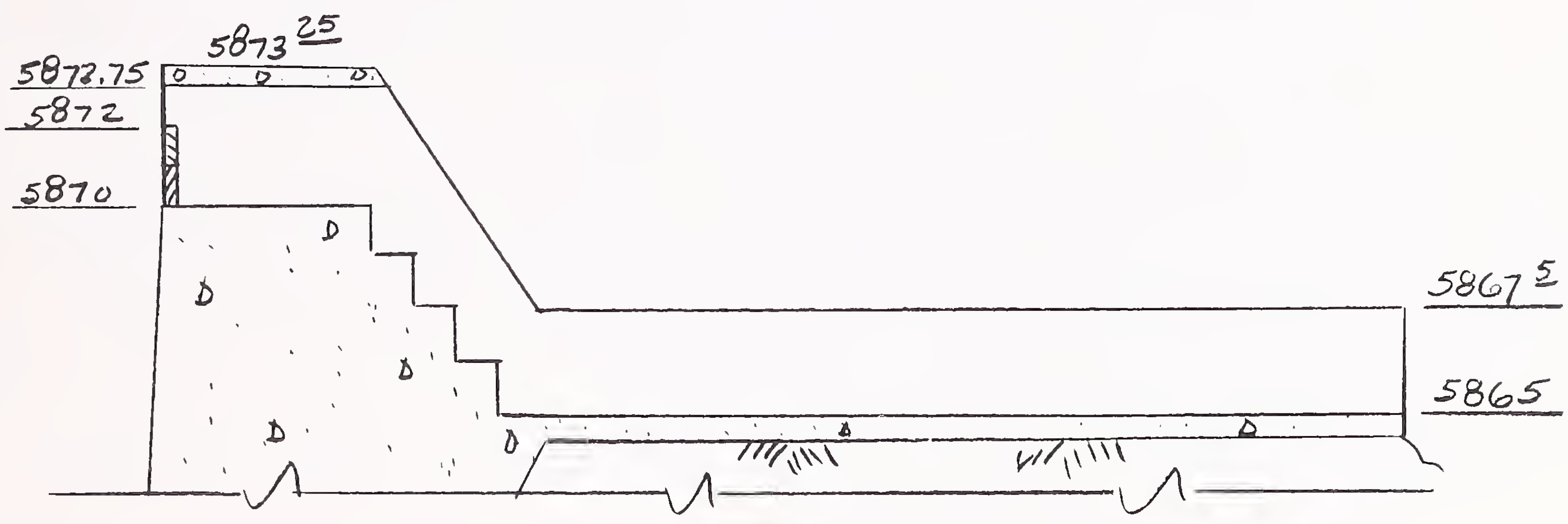
PLATE 7



PLAN- 1" = 5'

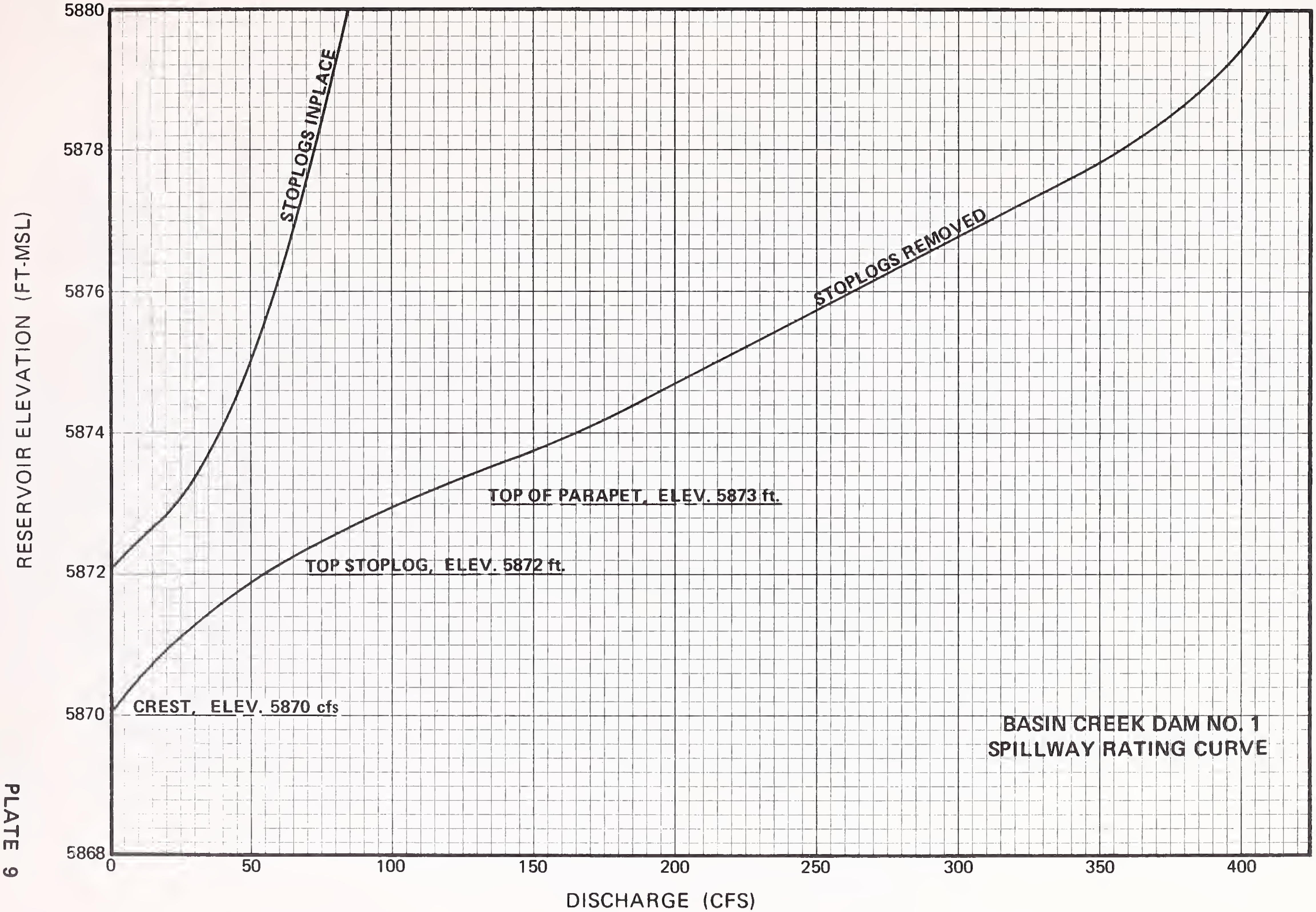


SECTION A-A
1" = 5'



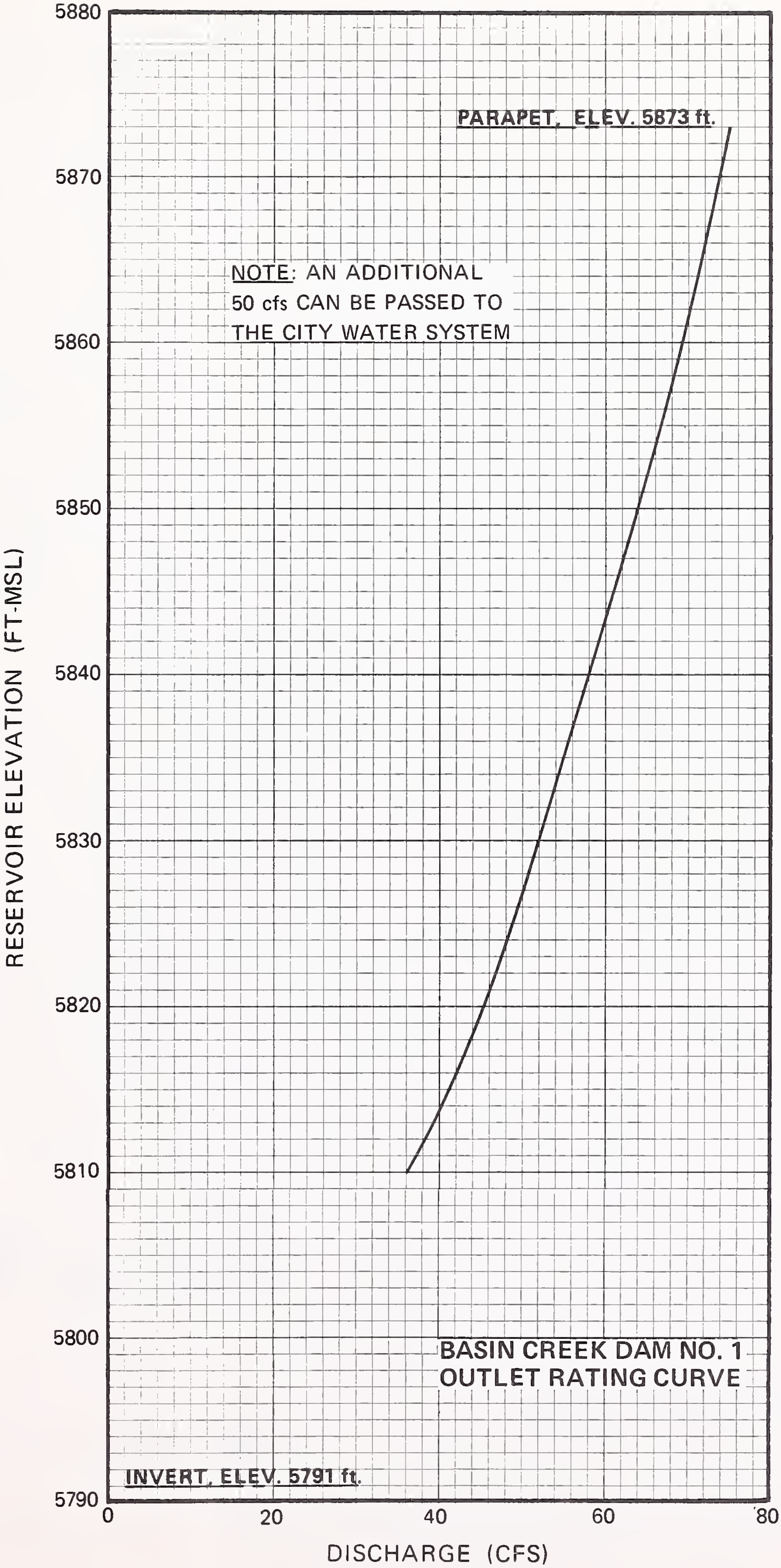
PROFILE- 1" = 5'

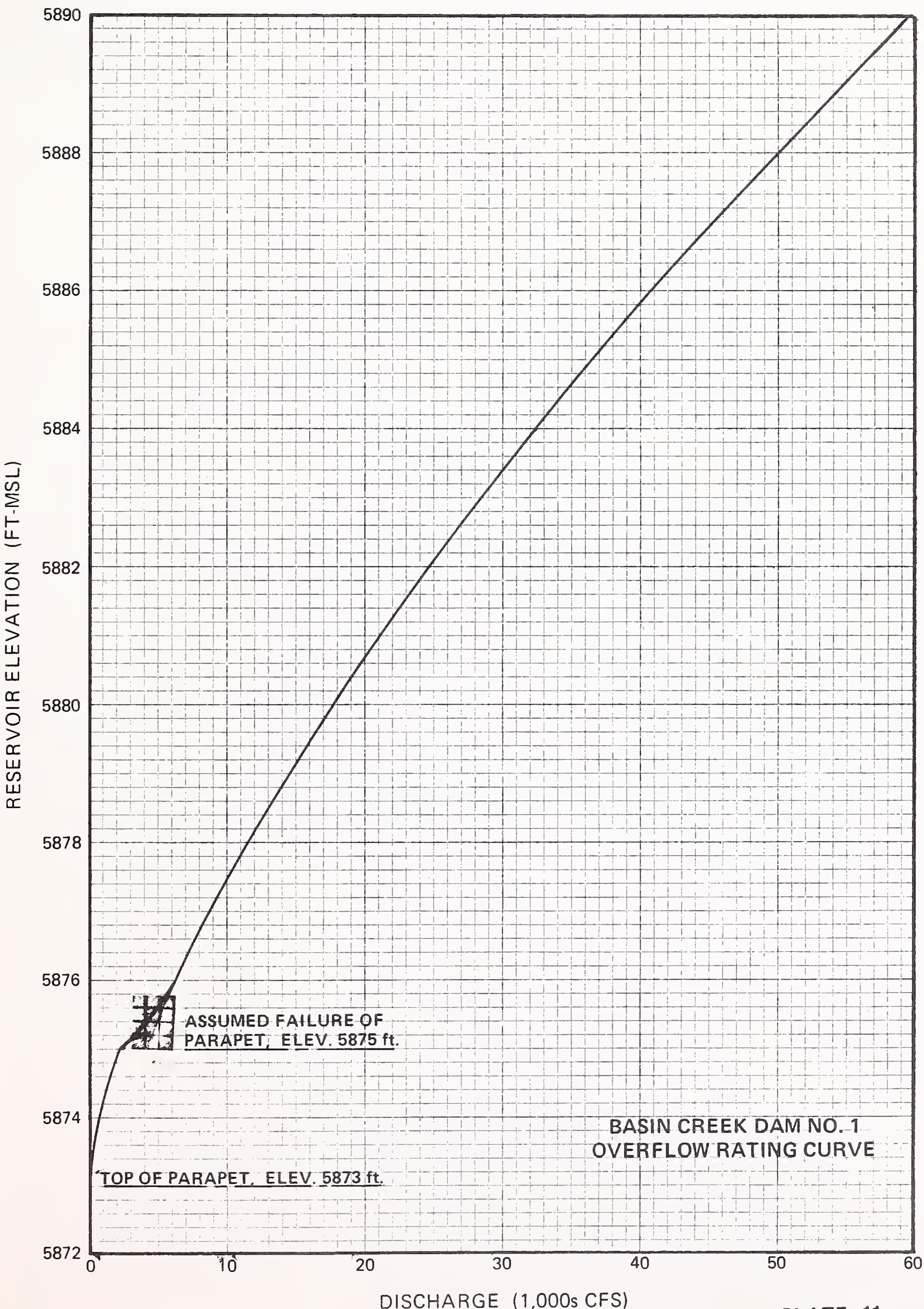
BASIN CRK DAM #1
SPILLWAY



BASIN CREEK DAM NO. 1
SPILLWAY RATING CURVE
STOPLOGS INPLACE
STOPLOGS REMOVED
TOP OF PARAPET, ELEV. 5873 ft.
TOP STOPLOG, ELEV. 5872 ft.
CREST, ELEV. 5870 cfs
RESERVOIR ELEVATION (FT-MSL)
5880
5878
5876
5874
5872
5870
5868
DISCHARGE (CFS)
0
50
100
150
200
250
300
350
400

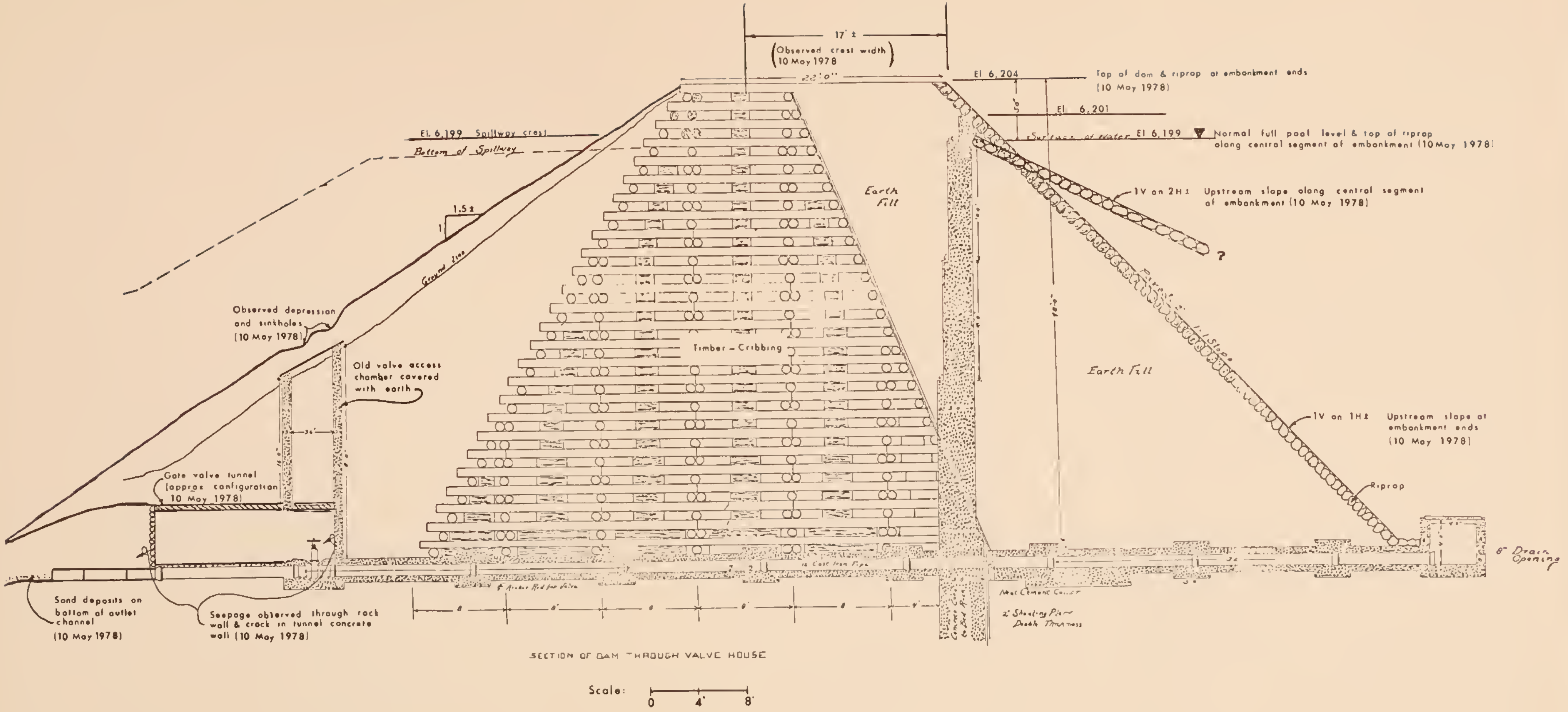
PLATE 9


PARAPET, ELEV. 5873 ft.
NOTE: AN ADDITIONAL 50 cfs CAN BE PASSED TO THE CITY WATER SYSTEM
BASIN CREEK DAM NO. 1
OUTLET RATING CURVE
INVERT, ELEV. 5791 ft.
RESERVOIR ELEVATION (FT-MSL)
DISCHARGE (CFS)
5880
5870
5860
5850
5840
5830
5820
5810
5800
5790
0
20
40
60
80



RESERVOIR ELEVATION (FT-MSL)
5890
5888
5886
5884
5882
5880
5878
5876
5874
5872
ASSUMED FAILURE OF PARAPET, ELEV. 5875 ft.
TOP OF PARAPET, ELEV. 5873 ft.
BASIN CREEK DAM NO. 1
OVERFLOW RATING CURVE
0
10
20
30
40
50
60
DISCHARGE (1,000s CFS)

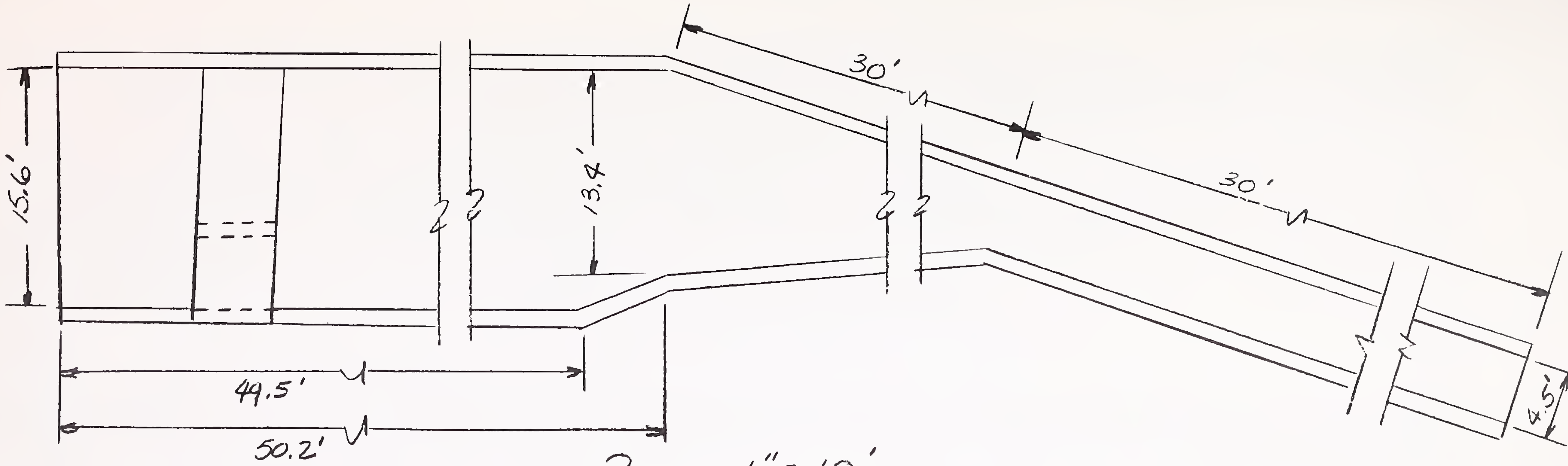
PLATE 11



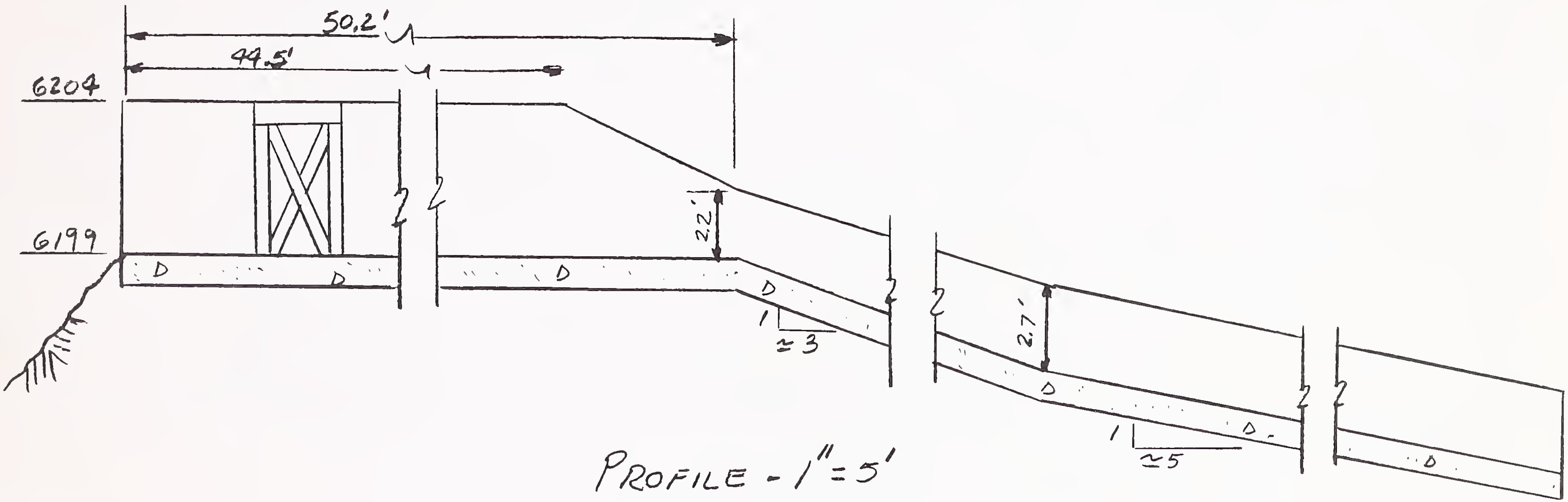
NOTE

Drawing has been modified to show conditions observed on 10 May 1978

BASIN CREEK DAM NO. 2

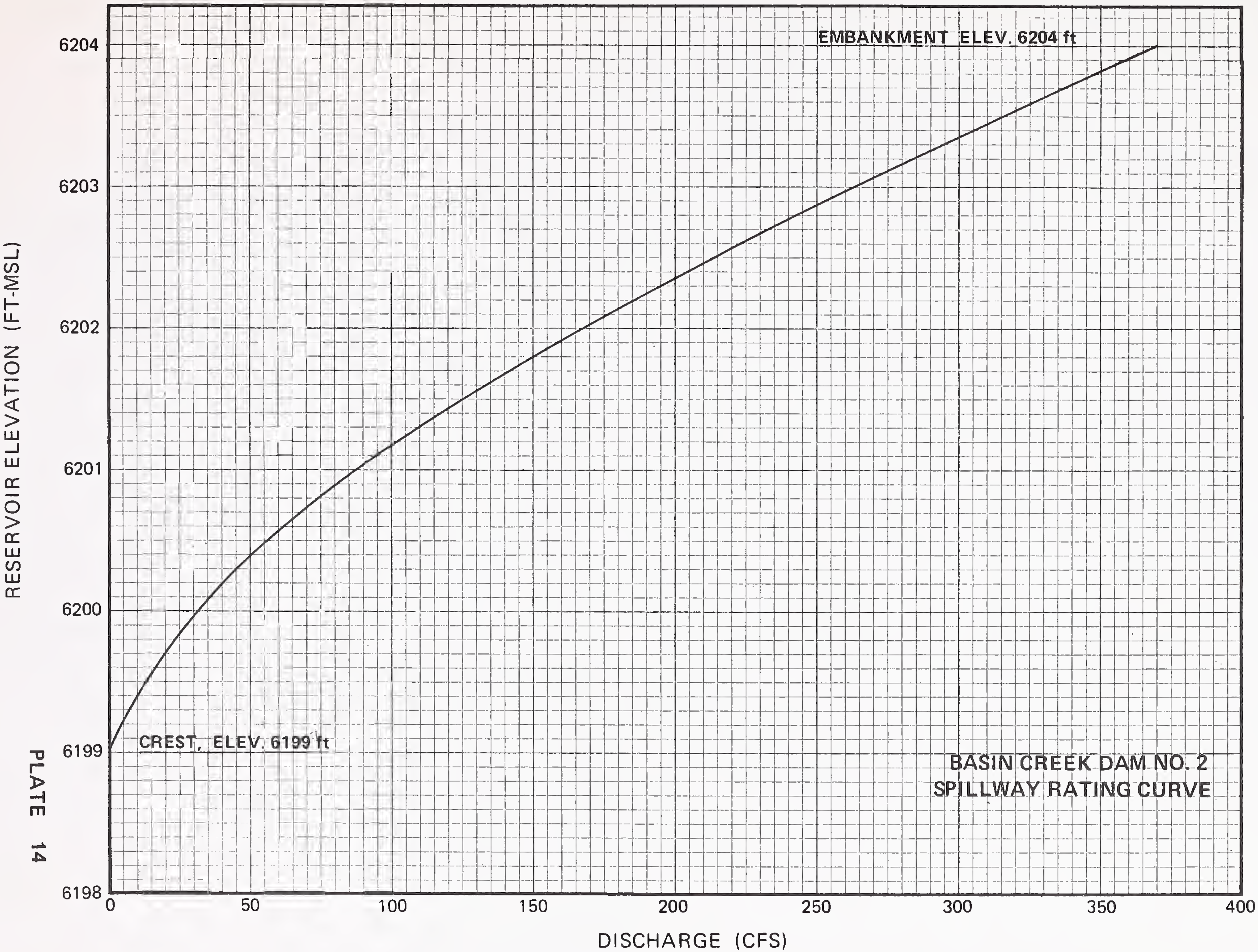


PLAN - 1" = 10'



PROFILE - 1" = 5'

BASIN CRK DAM #2
SPILLWAY


EMBANKMENT ELEV. 6204 ft
CREST, ELEV. 6199 ft
BASIN CREEK DAM NO. 2
SPILLWAY RATING CURVE
RESERVOIR ELEVATION (FT-MSL)
6204
6203
6202
6201
6200
6199
6198
DISCHARGE (CFS)
0
50
100
150
200
250
300
350
400